AGRICULTURAL ENGINEERING

MAY • 1951

Development of Idaho Potato Harvesting Combines *J. W. Martin and E. N. Humphrey*

The Utility of Hydraulic Power with Track-Type Tractors *Frank P. Hanson*

New Concepts in the Development of Side-Delivery Rakes *Roy Bainer*

A 20-Year Study of Wind Damage to Farm Buildings *M. L. Esmay and Henry Giese*

Application of Radiant Energy to Brooding Chicks *K. C. Seeger and J. H. Oliver*

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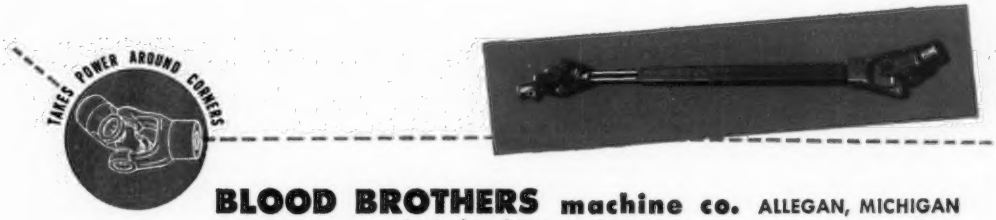

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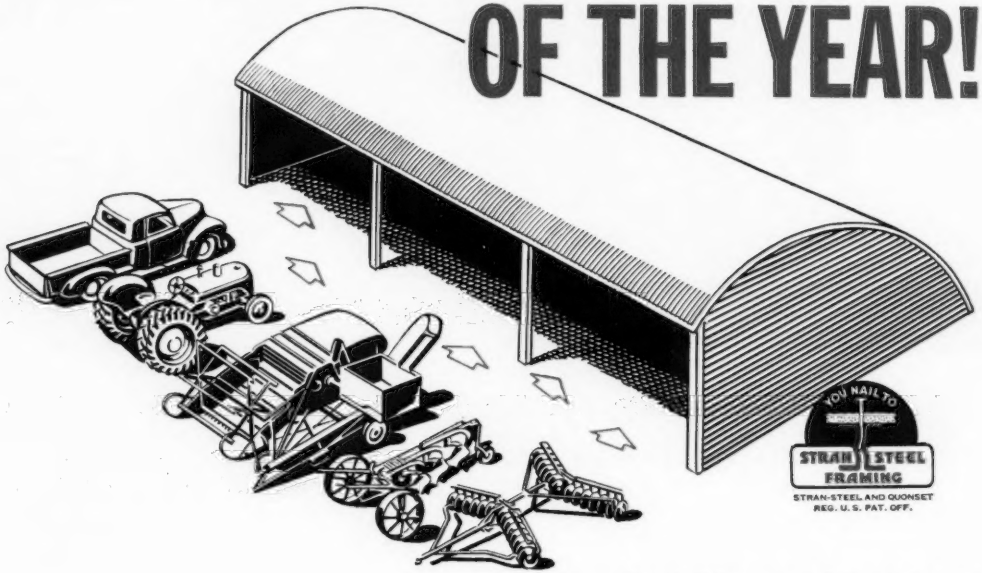

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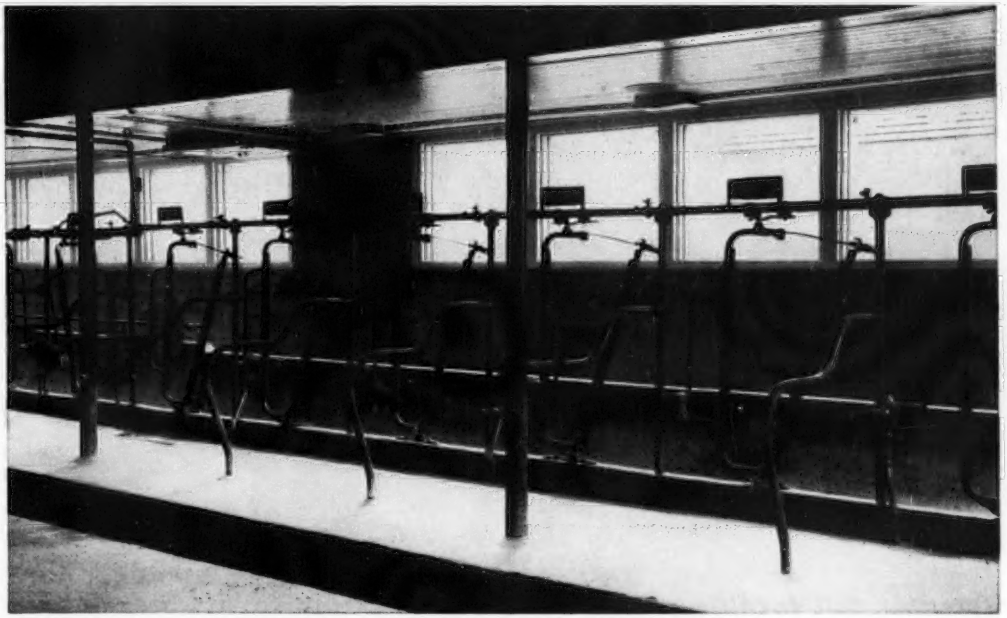

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- less condensation means cleaner windows, and thus more daylight brought in.
- *Thermopane's* insulation helps guard against cold. More sun heat and animal heat is *kept* inside.
- drafts at windows are reduced because of the warmer inner pane. With warmer air, the ventilating system carries off moisture more efficiently.

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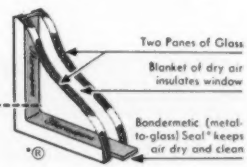

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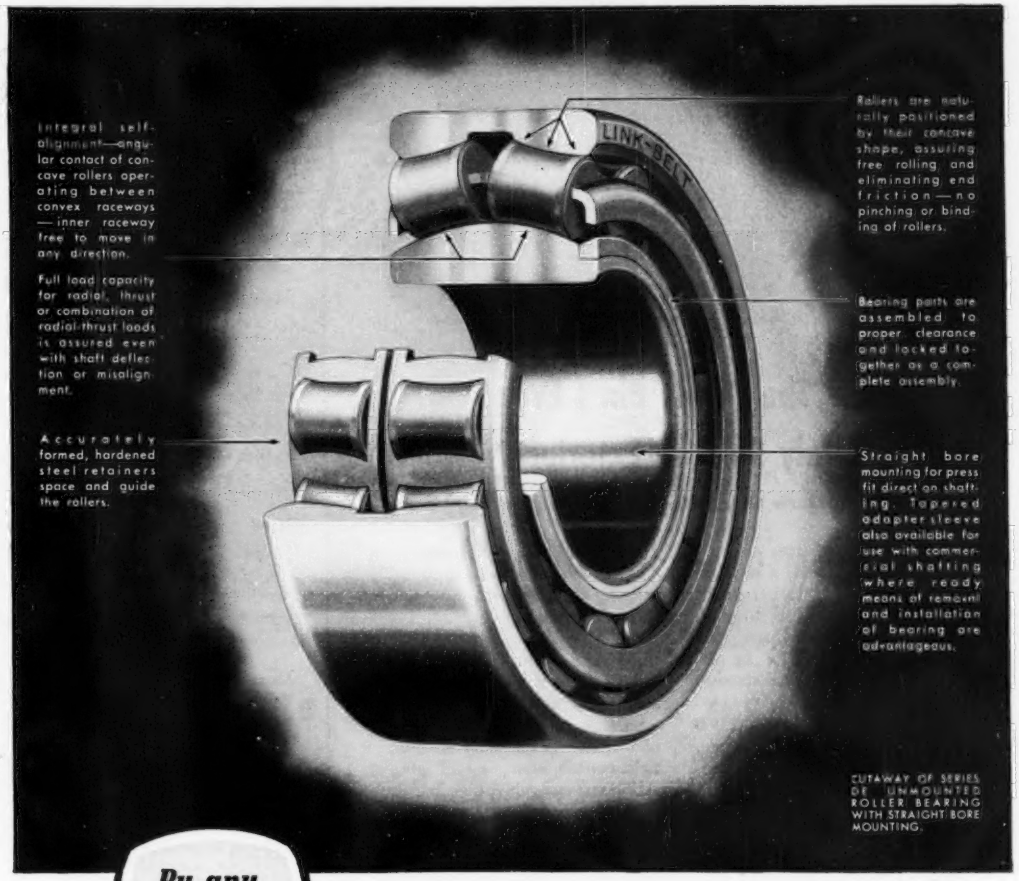
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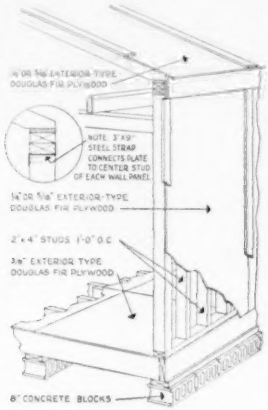
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NOTE: 3"x9" STEEL STRAP CONNECTS PLATE TO CENTER STUD OF EACH WALL PANEL
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8" CONCRETE BLOCKS

Above is a cross-section detail from Midwest Plan 73294. Bin is 16′x20′ with walls 8′ high. Walls and gable ends are formed with twenty panels of ¼″ Exterior-type Douglas fir plywood (the type which should be used for ALL farm service structures; Exterior-type panels are bonded with completely waterproof adhesives for permanent exposure to weather, water or abnormal moisture conditions). The floor is constructed with ten ⅜″ Exterior plywood panels 4′x8′, the roof with ten ¼″ panels 4′x9′. Doors and cover require ¼″ panel 3′x7′. Capacity of the structure is 2,000 bushels. A multi-purpose building easily constructed on the site, or it may be prefabricated and demountable.

"This Is The Driest Bin I Ever Had. I'm Completely Sold on Exterior Plywood,"

Says Theodore Gruenhagen, Davenport, Iowa

SAFE storage for grains of every type continues to be a problem throughout the country. Mr. Theodore Gruenhagen, Route 1, Davenport, Iowa, found that a bin of Exterior-type Douglas fir plywood provides a very satisfactory answer.

Mr. Gruenhagen's bin is a 2,000 bushel rectangular structure, designed for easy on-site construction or prefabrication with Douglas fir plywood. The only deviation from the original plan is in the foundation. Mr. Gruenhagen's bin is on a poured concrete foundation instead of concrete blocks, a change recommended when bin is to be at a permanent location.

Commenting on the bin, Mr. Gruenhagen says: "Structurally it is fine. It was filled with shelled corn in the fall of 1949 and gave excellent protection. This last year I used it for storage of sacked certified Shelby oat seed, my most valuable crop. It's tight and tough, the driest bin I ever had. I'm completely sold on Exterior plywood for grain bin construction."

Thousands of grain bins of every size have been built with Exterior-type Douglas fir plywood. They offer these primary advantages: tight construction, ease of fabrication and assembly, high tensile strength plus lightness and resistance to racking, resistance to vermin, adaptability to other farm uses, proved durability, long life.

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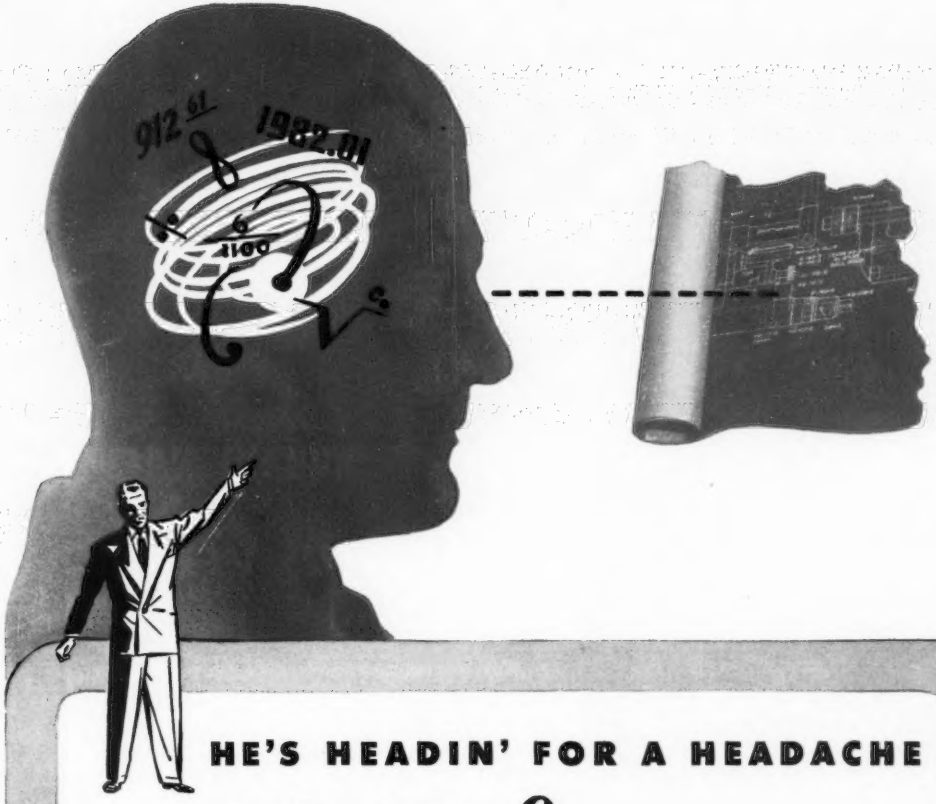

HE'S HEADIN' FOR A HEADACHE

.....*are you?*

Nearly every design engineer has had the same experience—developed a seemingly "perfect" new machine right up to the final blue print stage only to find hidden "bugs" that spell trouble ahead.

Often these "bugs" stem from bearings—their improper or inadequate application, *THAT IS!*

Most engineers, when confronted with anti-friction problems, turn to specialists—engineers who have accumulated years of experience and "know-how" in this one field. Such is the caliber of Aetna's engineering staff. Thanks to them, leading machinery manufacturers often save months of needless time, effort and expense in product development.

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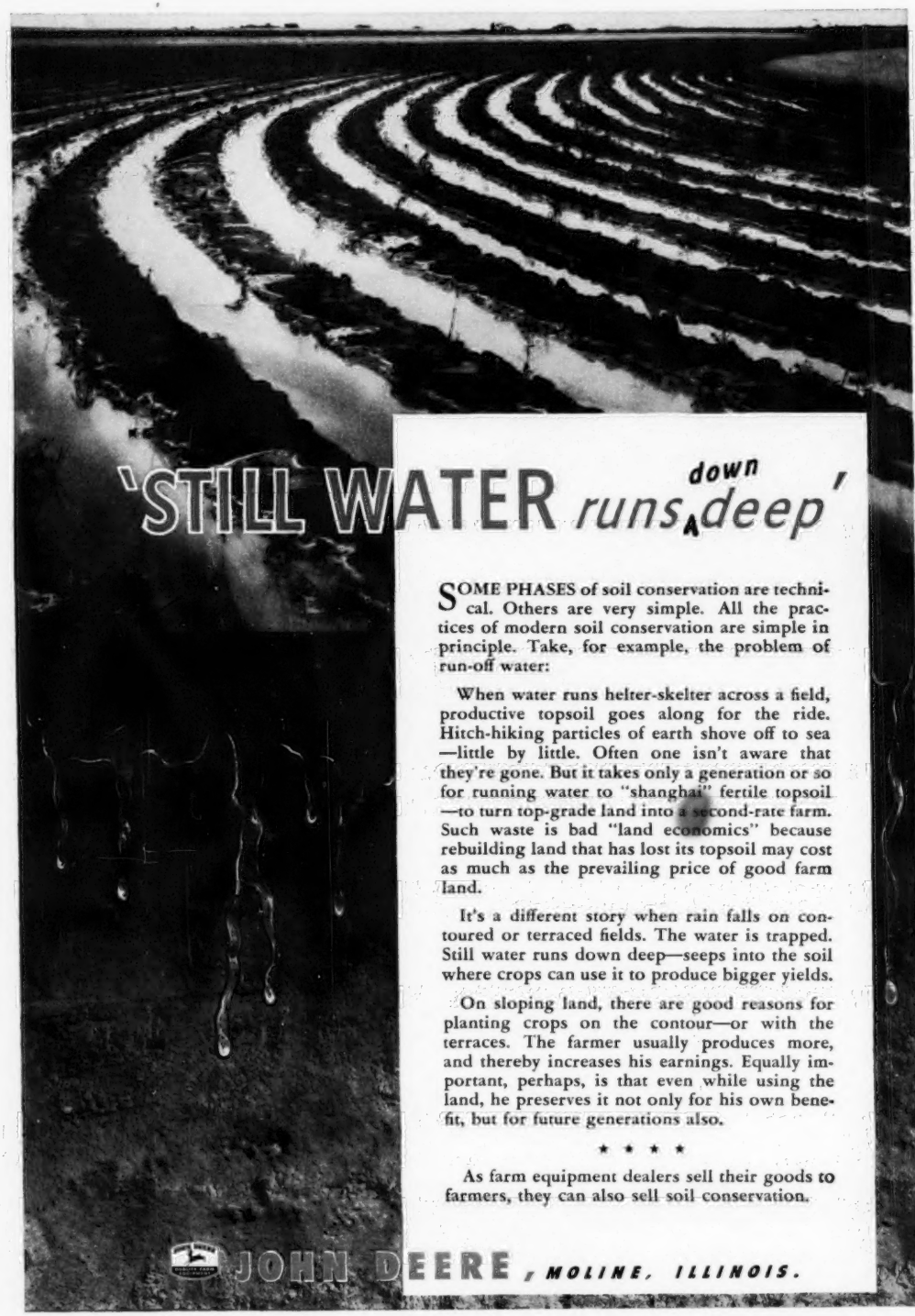

'STILL WATER runs down deep'

SOME PHASES of soil conservation are technical. Others are very simple. All the practices of modern soil conservation are simple in principle. Take, for example, the problem of run-off water:

When water runs helter-skelter across a field, productive topsoil goes along for the ride. Hitch-hiking particles of earth shove off to sea —little by little. Often one isn't aware that they're gone. But it takes only a generation or so for running water to "shanghai" fertile topsoil —to turn top-grade land into a second-rate farm. Such waste is bad "land economics" because rebuilding land that has lost its topsoil may cost as much as the prevailing price of good farm land.

It's a different story when rain falls on contoured or terraced fields. The water is trapped. Still water runs down deep—seeps into the soil where crops can use it to produce bigger yields.

On sloping land, there are good reasons for planting crops on the contour—or with the terraces. The farmer usually produces more, and thereby increases his earnings. Equally important, perhaps, is that even while using the land, he preserves it not only for his own benefit, but for future generations also.

★ ★ ★ ★

As farm equipment dealers sell their goods to farmers, they can also sell soil conservation.

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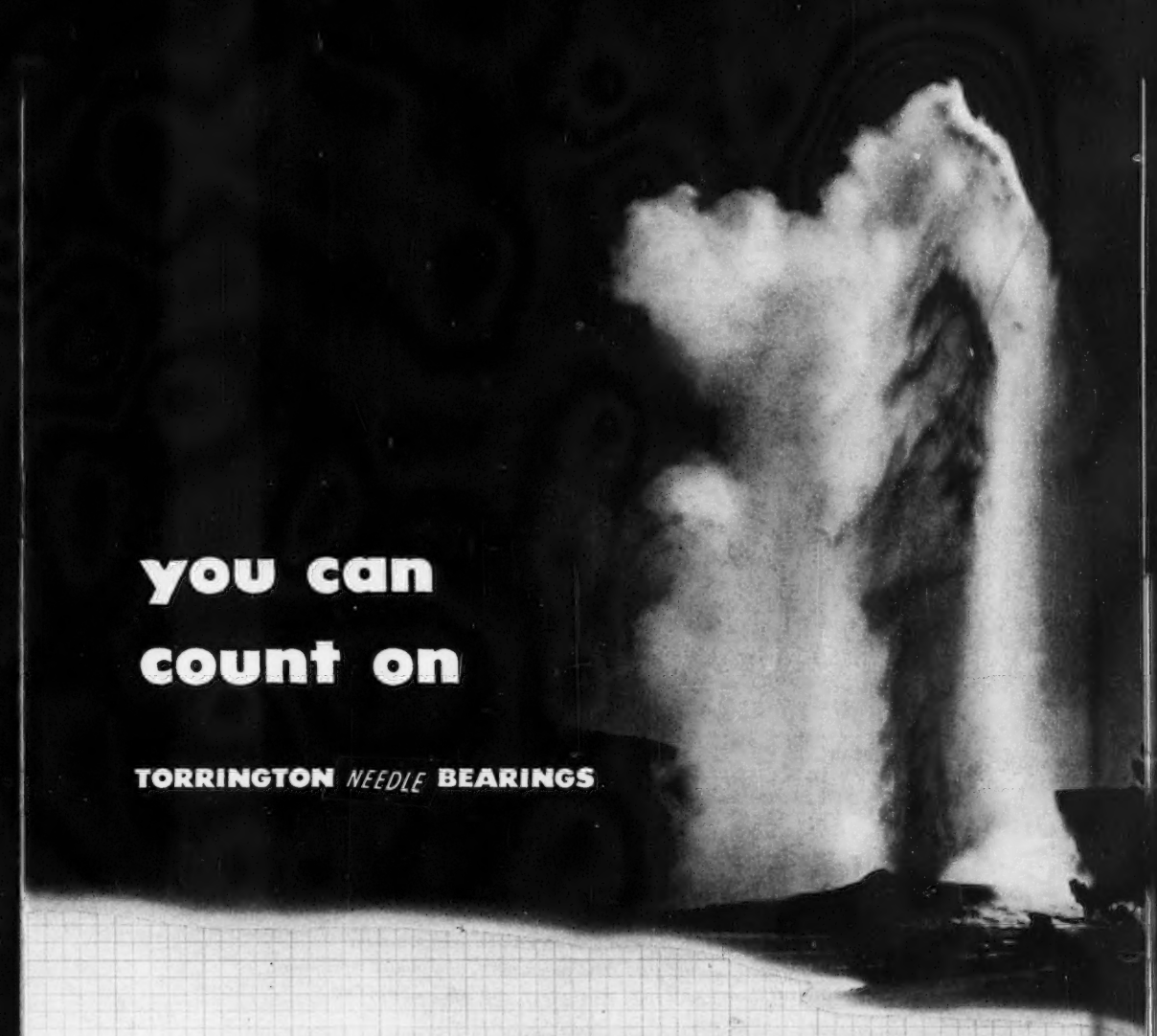

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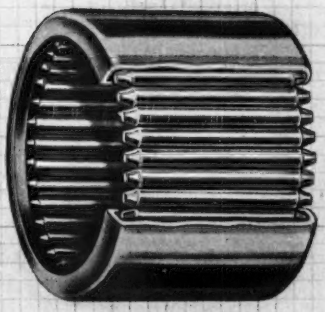

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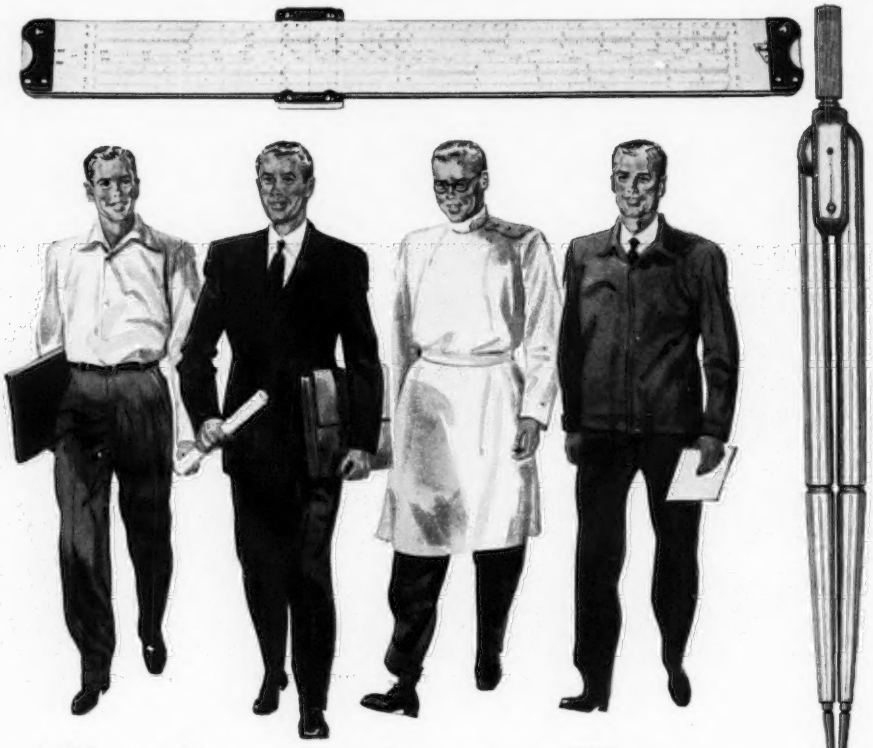

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MECHANICS UNIVERSAL JOINT DIVISION

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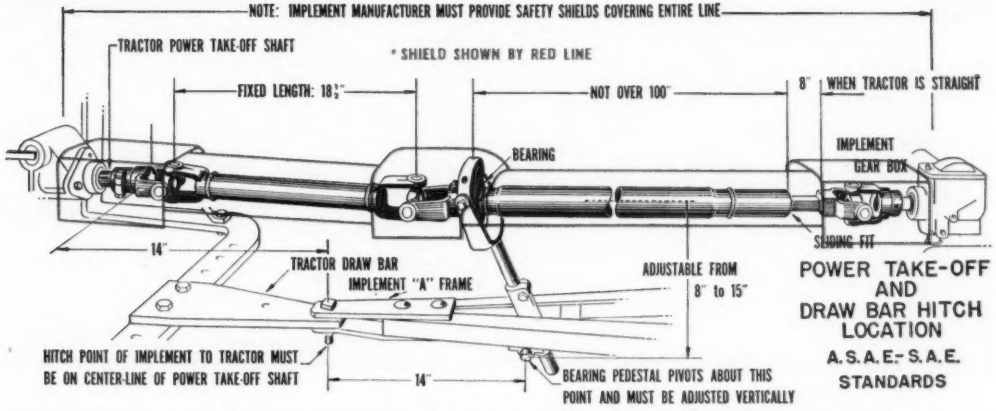
NOTE: IMPLEMENT MANUFACTURER MUST PROVIDE SAFETY SHIELDS COVERING ENTIRE LINE
TRACTOR POWER TAKE-OFF SHAFT
* SHIELD SHOWN BY RED LINE
FIXED LENGTH: 18½"
NOT OVER 100"
8" WHEN TRACTOR IS STRAIGHT
BEARING
IMPLEMENT GEAR BOX
SLIDING FIT
14"
TRACTOR DRAW BAR
IMPLEMENT "A" FRAME
ADJUSTABLE FROM 8" to 15"
HITCH POINT OF IMPLEMENT TO TRACTOR MUST BE ON CENTER-LINE OF POWER TAKE-OFF SHAFT
14"
BEARING PEDESTAL PIVOTS ABOUT THIS POINT AND MUST BE ADJUSTED VERTICALLY
POWER TAKE-OFF AND DRAW BAR HITCH LOCATION
A.S.A.E.-S.A.E. STANDARDS

SIZE	TYPICAL APPLICATIONS	RATED H.P. AT 532 R.P.M.
1½ RA	1 - 2 Row Corn Picker — Binders — Small Combines	10 H. P.
2 RA	2 Row Corn Picker — Binders — Large Combines — Windrows	20 H. P.
3 RA	Large Balers — Ensilage Harvesters — Roto Beaters — Etc.	30 H. P.

All drive lines can be supplied with safety slip clutches which can be set for any torque needed.

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EDITORIAL

Soil as an Engineering Material

BECAUSE of its wide range of characteristics, soil has been one of the most troublesome of materials entering into the calculations of engineers.

Of all the branches of engineering, agricultural engineers are probably most concerned with soil in terms of acreage involved; number and significant combinations of its physical, chemical and biological characteristics; and the variety of engineering designs and operations and economic purposes influenced by its characteristics.

This will give agricultural engineers a substantial interest in a new approach to the study of soil as an engineering material. This study in progress in New Jersey* is developing data on the properties of soils of interest to engineers, expressed in ranges of value rather than in precise values. It is believed that "this departure from the usual method of cataloging the properties of engineering materials" will make it possible "to provide the engineer with a means for identifying, classifying, and evaluating the engineering qualities of soil materials."

While this method is being applied to the soils of New Jersey and to the properties of particular interest in road building, some of the resulting data may prove more broadly useful. Further, the method may prove applicable to other areas and to other properties of soils of primary interest to agricultural engineers.

An Expanding Agriculture

TO DATE increased mechanization of agriculture has resulted in, or has been associated with relative and actual decreases in farm population.

Our nation has lost something in farmers as a dominant element of its population. It has lost some of their strength and character as rugged, pioneering individualists. Our cities have lost a great deal of their farm source of rejuvenating strength and leadership. The farm is now attractive to many of the best qualified in its new generations.

There is little point in arguing whether or not this price of progress has been too high. Farmers will not be denied the right to work effectively for their individual material and social advancement. The question is, "Where do we go from here?"

In answer, a number of leaders have proposed the substantial enlargement of agriculture, its development in the direction of rendering increased economic service.

Agriculture's room for expansion is in the direction beyond primary production of traditional food and fiber materials. Its potential market is in present and potential uses for materials from organic sources which are or may be produced in quantity under farm conditions, at prices which encourage increased use.

Wheeler McMillen, at the National Farm Chemurgic Conference last month, reemphasized as an important aspect of chemurgy this opportunity for the further development of agriculture. In recent years science and industry have given us dozens of examples of their capacity to work with agriculture for the production of new and increased material values from farm sources.

Howard Doane has given the name "vertical diversification" to the extension of farm operations beyond primary production. In economic significance it means earning a larger proportion of the consumers' dollar by doing more on or near the farm to give consumers what they want in farm products as to form, condition, time and place of delivery, and cost. It means the farm handling of more of the jobs on a longer section of the agricultural commodity production line. Examples include the sale of grain and hay in the form of meat, milk, and eggs; the farm cleaning, sorting, grading, grinding, cutting, mixing, drying, pasteurizing, fast freezing, packaging, and delivery of various products to the extent that such operations are desirable and can be performed effectively and economically by farmers.

To agricultural engineers this will suggest further thought in terms of farm processing; farm applications of industrial engineering principles; processing equipment, structures, operations, instrumentation and controls, utilization of residues, and storage and delivery of products, all scaled to the individual farm and farm community.

Progress in expanding the economic service rendered by agriculture may not be revolutionary or even rapid. It takes time to work out operations and related equipment which meet the test of economic soundness. Increasing the efficiency of agriculture in primary production has been a long, slow, evolutionary process. Extending its efficient operation beyond primary production will also be an evolutionary development.

Progress in primary production economy, making farms a more desirable place for fewer people to live and work, has been an important but sometimes painful step in our national economic development. The expansion of agriculture's economic functions, making farms a desirable place for more people to live and work, seems a natural and desirable sequel. It shows promise of economic and social advantage to the nation, as well as to increased numbers of individual farmers.

War Economy

AS IS common when war is in the wind, we again hear talk to the effect that a war economy is being encouraged by business as the only alternative to depression.

This seems to us to reflect irresponsible and loose thinking on the subject. Just how prevalent the idea may be, how generally it may be held by business men, or to what extent it may be maliciously promoted by subversive influences, we do not pretend to know. We believe it indicates dangerous thinking or lack of thinking for men armed with votes. It might well be countered by every available means.

So far as we can see, there is nothing in our economy of production and exchange for human use which inherently requires a periodic boost in the form of war to keep it running. Review of the fundamental mechanics of our free enterprise economy may be one effective way of stimulating constructive thought on the subject.

Individually we produce primarily to provide what we want for our current and future use. The satisfactions of consumption are our individual incentives for production.

We strike a balance between our exertion to produce, our interest in saving for our future security some part of what we have produced, and our natural desire to consume and enjoy something more than the minimum necessities of life.

Nature's resources are not so abundant, our efficiency so high, our incentives to produce so strong, our capacity to enjoy consumption so limited, nor our time on earth so ample that we need to waste or destroy any of the values we have produced simply to get them out of the way so we can produce more.

In principle there is no economic necessity for waste! There is no economic justification for production and consumption without the realization of human satisfactions. Production for its own sake is pointless.

We submit that this is true for people collectively as well as individually. It seems to follow that it should be true nationally and internationally. Whatever the causes and results of war, it is not necessary in order to clear the decks for further production.

Depression is not a surfeit of goods or values above our human capacity to enjoy or anticipate future use. It is a lack of confidence in our ability to produce, exchange and save new values. *(Continued on page 290)*

*Engineering Soil Survey of New Jersey, Report No. 1, Engineering Research Bulletin No. 15, Rutgers University (New Brunswick).

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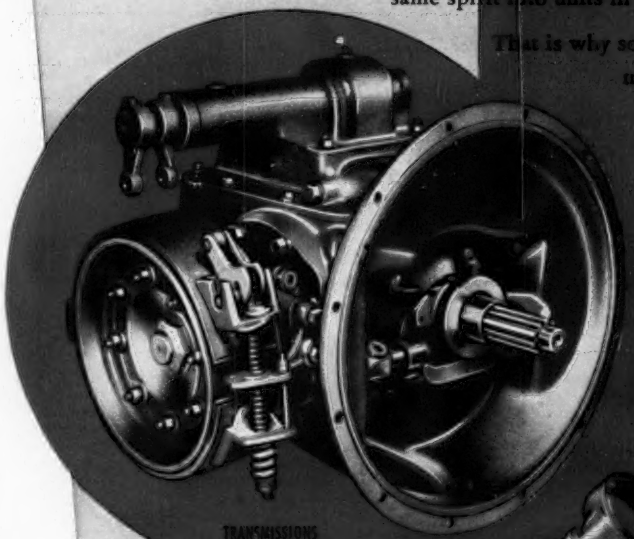

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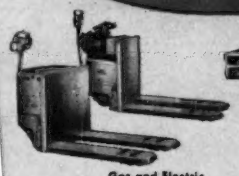
Rear Axle Housings

Front Axles for Trucks, Busses and Tractors



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AGRICULTURAL ENGINEERING

VOL. 32 MAY, 1951 NO. 5

Development of Idaho Potato Harvesters

By J. W. Martin and E. N. Humphrey

MEMBER A.S.A.E. MEMBER A.S.A.E.

FARMERS in several counties of Idaho are using a large number of potato combines. These machines are either digging-sacking or digging-bulk-handling units. Interest in the various potato-growing sections is towards some type of mechanization rather than to continue the laborious and expensive method of digging and hand picking.

Development of mechanical harvesting equipment has been left largely to the individual farmer. Practically all of the potato combines now in use have been built in the farm shops by farmers or in local job shops by mechanics from ideas developed by farmers.

In 1947 the Idaho Advertising Commission and the Idaho Agricultural Experiment Station jointly sponsored a research project to study ways to improve mechanical harvesting, sorting, and grading of potatoes. At the start of the project, a survey was made to determine the approximate number of home-built machines in use. The results are summarized in Table 1.

TABLE 1. USE OF MECHANICAL POTATO HARVESTERS

	1945	1946	1947	1948	1949
Number of harvesters in use	283	419	759	1,200	1,450
Acres of potatoes planted	184,452	176,235	144,807	150,000	144,000
Acres of potatoes harvested mechanically	9,765	17,275	31,175	60,000	72,000

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Washington, D.C., June, 1950, as a contribution of the Power and Machinery Division. The project reported in this paper was made possible by funds provided by the Idaho Advertising Commission, by the Idaho Agricultural Experiment Station, and under the Research and Marketing Act of 1946. Publication of this paper is approved by the Director of the Idaho Agricultural Experiment Station as Research Paper No. 328.

The authors: J. W. MARTIN and E. N. HUMPHREY, respectively, agricultural engineer and formerly associate agricultural engineer, Idaho Agricultural Experiment Station, Moscow.

The main approach to the problem of mechanical harvesting of potatoes was to give engineering assistance to individual farmers wanting to build a potato combine. The engineering assistance consisted of sketches, special equipment for field trials, rubber for padding the digger, piler, and chain links, and the use of special tools. The farmers furnished materials and labor and did the actual building of the machine. The engineer visited the farms several times each week during construction of the machine. By this arrangement different models and several machines of each model could be built and tested during one harvest season. Farmers were willing to give the plan a try.

An entirely new separating mechanism was devised that would separate dirt from potatoes more effectively and do it without injuring the potato. Dirt separation from potatoes had previously been done on a vibrating chain belt. The new method used rubber rolls to separate dirt from the stream of potatoes. The advantages of this are gentler action and practically no potato injury, greater separating capacity per square foot, more positive separation, and better operation under damp and muddy conditions.

During the first year of the project, all efforts were directed toward designing a single-row sacking machine for trials at the Aberdeen (Ida,) Branch Experiment Station. After a careful study of the desirable features the following principles were set up for the design:

1 Separate the soil from the potatoes on rubber rolls after they had traveled up a rubber-coated digger chain

2 Keep the potatoes on rubber from soil to sack

3 Use rubber padding to cushion the potatoes

4 Use rubber tubing cemented to the digger chain links

5 Allow the potatoes no free fall of over 6 in

6 Reduce the operating speed and carry a cushion of soil up the digger chain.

During the winter months, plans were drawn covering the basic design of four models of potato harvesters. These

Fig. 1 *(Left)* Single-row sacking model of Idaho potato harvester as used during the initial field trials • Fig. 2 *(Right)* Rubber separating rolls as used on the original single-row sacking machine. Note the rubber belt shielding over the digger chain ends and over the ends of the rollers, also the rubber-covered digger chain. The star roll can be seen in its relation to the digger chain

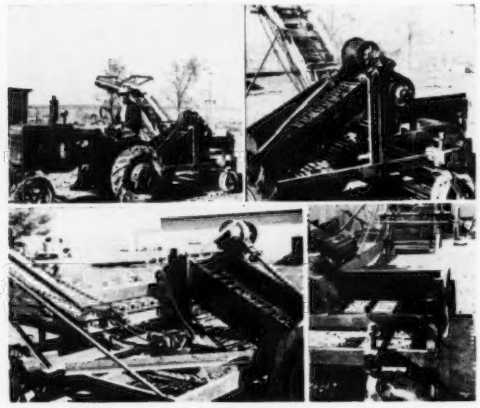

Fig. 3 The single-row bulk harvester. *(Upper left)* Completed machine ready for field trial during the 1949 harvest. *(Upper right)* Power take-off drive as seen from the left side. *(Lower left)* Power take-off drive and rubber separating rolls as seen from the right side. *(Lower right)* Rubber separating rolls, elevator and rear platform

machines were designed to operate on small and large farms and to operate under adverse as well as favorable conditions. These machines were named as follows:

1 For the small operator, a single-row, digging-sacking machine that places the potatoes in half-sacks as they are dug

2 For the small operator, a single-row, bulk-handling machine that elevates the potatoes into a bulk-handling truck at the side of the digger

3 For the large operator, a two-row, light-duty, bulk-handling machine. This machine was not intended to operate where rocks or large, hard clods were a problem

4 For the large operator, a two-row, heavy-duty, bulk-handling machine. This machine was intended to operate in the most severe conditions of rocks and clods.

SINGLE-ROW SACKING MACHINE

The first machine was built around a standard 26-in Oliver digger. The frame was altered to allow for the rubber separating rolls, the picking platform, and the sacking device. Fig. 1 shows the completed digger ready for field trials during the 1948 harvest season.

Since the other three models were designed around the features of the single-row sacking unit, a more detailed discussion will be given covering this first machine.

Height. The height of the machine is important. First, it controls the angle of the digger chain, and, second, it controls the ease with which the operator can work. If the machine is too low, the operator must work in a bent-over position. The highest point of the digger chain is 44 in from the floor, and the highest point of the frame is 57 in from the floor. This is a good compromise between elevator height and ease of working.

Length. When operating in small fields the over-all length is important. One of the disadvantages of the trailer picker is the extreme length and difficulty of turning and backing. The length from the lower end of the digger chain to the rear of the main frame is approximately 14 ft. The rear platform extends back an additional 40 in. The over-all length is 21 ft from the tractor hitch to the rear of the sacker platform.

Digger Chain. The face of the digger chain is approximately 7½ ft long by 26 in wide. The whole chain consists of 130 rubber-coated links. The links were coated commercially by the vulcanizing process in Portland, Ore., by the Huntington Rubber Mills.

A hinged joint is located 31 in from the center of the cone chain-carrier roller on the lower end of the digger apron. This joint allows the digger point to be raised free of the ground for transporting and also allows the operator to change the depth of operation. Depth control was secured by means of a standard-type lever or through the operation of a hydraulic cylinder.

The rubber separating rolls for separating loose soil, clods and short stems from the potatoes are shown in Fig. 2. On the original model this mechanism consisted of 6 smooth rubber rolls, each 3 in in diameter by 26 in long, spaced 1¼-in apart, plus one star roll 3¾ in in diameter. The star roll is placed as close to the digger chain as possible and operates at a higher speed than the other rolls. The purpose of this roll is to prevent plugging at the point of delivery from the digger chain to the rubber roll separator and especially to move any vines or stems that have not been picked off the digger chain.

The smooth rolls were made by mounting rubber washers 3 in in diameter by ⅛ in thick on high-carbon steel shafts 1 in in diameter. The shaft ends were cut down to ¾ in to allow the use of smaller bearings. All rollers are mounted on sealed ball bearings. To increase the separating capacity of the digger, a later model used 13 rolls instead of six.

Separator Drive. The smooth rubber rolls are driven by two No. 60 steel roller chains on the right-hand side of the machine. In the original machine all rolls operated at different speeds. This was accomplished by driving each roll with a different sized sprocket. These rolls, from front to rear, had 14-tooth, 13-tooth, 12-tooth, 11-tooth, 10-tooth, and 9-tooth drive sprockets. Thus the rolls turn faster as the potatoes progress across them. The star roll operates faster than any of the rubber rolls, with an actual surface speed equal to or above that of the digger chain.

At a speed of 150 fpm on the digger chain, the serrated roll had a surface speed of 150 to 160 fpm; the average of the rubber rolls was 70 to 120 ft fpm. Later trials indicated that fixed roll speed was as satisfactory as variable speed.

Mounted on the under side and as close as possible to the rubber rolls are cleaners to prevent mud and dirt from clinging to the rolls. The cleaners were made from 1½x¼-in mild steel strap and were adjustable for height.

Power to operate the digging and separating machanism is delivered from the tractor through the power take-off mechanism. From the take-off shaft power is delivered to the digger gear set through a 1⅛-in drive shaft having two universal joints to take care of change in direction and permit turning the outfit.

Sacking Hopper. The sacking hopper on the rear is lined with sponge-rubber sheeting ⅜ in thick. The distance from the bottom of the hopper to the platform on which the sack rested while being filled is 24 in.

Sacking Platform. The sacking platform was made adjustable for height and hinged so that it would fold upward in case it struck an obstruction. The size of the platform was 53 by 40 in. It was made by bolting 2-in planks on a light

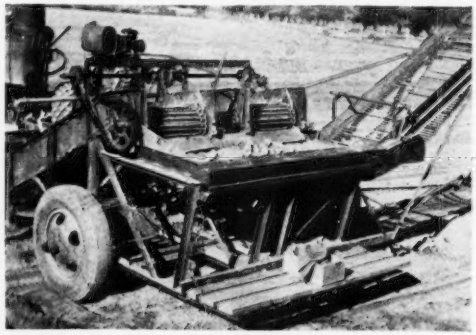

Fig. 4 Two-row, light-duty, bulk-handling harvester. Note the relation of the separating rolls to the digger chain and elevator. Work space has been provided for 3 workmen

metal frame and designed to carry the weight of the man operating the sacker as well as the weight of the sack of potatoes.

SINGLE-ROW BULK-HANDLING MACHINE

Many farmers are finding it a great saving in time and expense to handle the potato crop in bulk. To provide a machine for the smaller operator to bulk-handle his crop, a one-row unit was designed to be used wtih a small cultivating-type tractor. This machine when operated at a field speed of 1½ mph will harvest ½ acre per hour or from 4 to 5 acres per day.

This potato combine was designed to work with a tractor having a high rear axle. The International Harvester model A culti-vision tractor can pull the machine and operate the digger chain, separating rolls, and elevator from the power take-off shaft in average digging conditions. Fig. 3 (upper left) shows the complete machine ready for field trials.

Aluminum framing members were used in the separator and elevator to reduce weight. The entire elevator weighs only 470 lb. The reduction in weight was necessary to facilitate steering. The weight of the harvesting mechanism was carried on two rubber caster wheels on the rear of the machine.

The digging operation is performed under the center of the tractor, and the height of the digger point is controlled by the hydraulic system of the tractor.

The separator assembly is composed of 13 smooth rubber rollers mounted across the rear of the machine as shown in Fig. 3 (lower right).

In this machine the rolls moved the potatoes from the digger chain to the elevator as the dirt was eliminated. The rolls were 3 in in diameter and each turned at the same speed. A rear platform was provided for one or more operators to pick clods and rocks from the potatoes as they moved across to the elevator. The rubber rolls were driven at 90 to 150 rpm which gave a surface speed of from 70 to 120 fpm. With this arrangement, the rubber rolls will eliminate dirt, the short stems, and break up the softer clods. Only the hard clods and rocks must be picked out of the stream of potatoes.

The original machine was designed to be operated from the power take-off. However, after the first season's trial it was found that a separate engine would be an advantage. One 9-hp engine could operate the entire harvester mechanism. If more flexibility was wanted, two engines could be used, one to drive the digger chain and separating rolls and one small engine to operate the elevator. This would increase the overall weight of the machine but would allow reserve tractor power for wet and muddy field conditions. It would also give better speed control which is always an advantage in keeping bruises at a minimum.

The machine was designed for a field speed of 1½ mph and a digger chain speed of 132 to 150 fpm. The cost for the material used in building the machine was about $500. The out-of-pocket expense in harvesting potatoes was about 6c per 100 lb.

TWO-ROW BULK-HANDLING MACHINES

This machine was built in two different models. The original model used an Oliver two-row standard digger for the basic frame with the rubber separating rolls mounted across the back of the machine as shown in Fig. 4. A second model was designed without reference to any existing machine; however, the two models are similar in actual construction.

The machines were intended to operate in the lighter soil condition where rocks were not a major problem. The recommended field speed is 1½ mph. At this speed the machine will dig and elevate an acre of potatoes per hour in fields producing 200 to 400 sacks per acre. From field trials we have found that the rubber roll assembly operates better on a heavy yield than on a light yield of potatoes, and the machines equipped with the rubber-roll assembly could operate with muddier conditions than machines using standard digger chains. In addition, rubber-roll separation gave much less mechanical damage than separation on vibrating chains.

The harvester is powered by two small engines, one of 9 hp to drive the digger chain and rubber rolls and a second engine to drive the elevator. The throttle and clutch controls are located on the rear so that one man on the rear platform can control both engines.

Both models of the light-duty machine used a rubber-roll separating unit consisting of 18 smooth rolls and with every roll driven at the same speed. The machines were intended to work in fields that had been devined. There was no provision for vine removal on the digger apron of the machine, but a work platform is provided at the rear for two or three operators to work. These men can remove rocks and aid in smashing the hard clods.

The completed machine weighed almost 5,000 lb, and, if in current production, could be expected to sell for about $2,500. From records kept on the machine in operation, potatoes can be put into the storage cellar for approximately 10 cents per 100 lb.

TWO-ROW, HEAVY-DUTY, BULK-HANDLING MACHINE

This machine was designed for the severe operating conditions where rocks and clods are a problem. Space was provided for up to 9 men to ride on the machine and pick off rocks, clods, and vines.

The machine was built using the same basic principles as set up for the single-row sacking unit. It is essentially two single-row sacking units mounted side by side with a cross elevator to carry the potatoes into the bulk handling truck. A special split digger point was used on this machine. This point was found to aid in the digging operation when alfalfa roots were a problem. The depth of digging was controlled by hydraulic cylinders.

Two sets of rubber separating rolls were installed on the machine as shown in Fig. 5. These rolls consist of 12 smooth rollers and one special star roller. In order that operators could work at the sides of the machine, the left main wheel was set under the machine and a platform built on each side and across the back. These platforms provided space for at least three persons on each side and three persons on the rear, or a total of nine for picking if severe conditions were encountered.

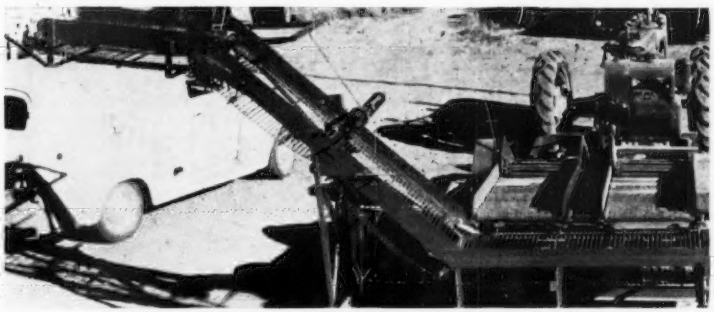

Fig. 5 The two-row, heavy-duty harvester. Note the one large 4-cylinder engine and the location of the separating rolls

The original machine was operated by using one 4-cylinder, 21-hp combine engine. In other models the power was supplied by two smaller engines. A 12-hp engine is used to drive the digger chains and separating rolls, and a 3-hp engine operates the elevator. This arrangement allows for better speed regulation and reduces mechanical injury to the potatoes. *(Continued on page 269)*

Utility of Hydraulic Power in Farming with Track-Type Tractors

By Frank P. Hanson
FELLOW A.S.A.E.

THE application of hydraulic power to track-type tractors in farming operations will be considered under four subheads, namely: (a) as part of the prime mover, (b) where the hydraulic jacks are part of the attached machines, (c) where the hydraulic jacks are movable or interchangeable between two or more machines, and (d) hydraulic motors.

Hydraulic power as applied to the prime mover will be found in hydraulic steering units and torque converters or hydraulic clutches. Although both hydraulic steering and torque converters are in commercial production on track-type tractors, such applications of hydraulic power will not be stressed in this paper. The application of hydraulic power where the jacks are fixed on machines attached to the tractor will be considered under various types of machines.

Loaders. Hydraulically controlled loaders are used to load manure and other farm materials. Perhaps all too frequently these machines are referred to as manure loaders when, as a matter of fact, one-man, high-capacity loaders are being demanded in increasiing numbers for many farm loading jobs.

Transportation of materials on farms has been considered from a mechanization standpoint as largely the horizontal movement of machines, products and materials. Vertical transportation on farms is coming into its own. Usually the light-duty loaders may be considered more of a tractor attachment, subject to the bucket assembly being removed to make the tractor more flexible for drawbar work. Some higher capacity loaders are intended to be attached to the tractor continuously.

Bulldozers. Bulldozers are most efficient when heavy materials are pushed distances not over 200 ft. In addition to building ponds, the bulldozer with hydraulic controls has many other uses on farms such as leveling, making and cleaning small ditches, removing trees and brush from fields or fence lines, concentrating manure for loading, making and servicing farm roads, filling gullies, moving large boulders and removing snow.

Ditchers. Some hydraulically controlled machines used to build and service ditches of rather large cross section are equipped with hydraulic pumps powered by separate engines. However, when the tractor can be closely coupled to the ditching machine, the hydraulic pump can be located on the tractor.

Tool Carriers. Some of the larger deep-tillage machines require hydraulic jacks with capacities greater than can be secured with (ASAE-SAE) standard jacks. Heavy-duty tool carriers equipped with chisels, subsoilers, mole drains and ditchers are being used with tractors of large drawbar horsepower.

Scrapers. Hydraulic scrapers especially built for the smaller track-type tractors are being used by farmers not only for pond building but also ditching and leveling. Irrigation in this country used to be confined to western areas with low annual rainfall, but today thousands of acres east of the Rocky Mountains are being prepared for irrigation by flooding and furrows.

Special Applications. There are numerous special heavy-duty and large-capacity agricultural machines whose usefulness and feasibility are determined largely by the application of hydraulic controls. Fig. 1 shows a hydraulically controlled plow with 44-in-diameter disks. It can be equipped with three, four or five disks. The five-disk unit weighs 12,000 lb. The three-disk unit is shown plowing 20 in deep in Texas. A spring-shank cultivator 45 ft wide is equipped with single-acting hydraulic jacks. The heavy-duty moldboard plow shown in Fig. 2 is plowing 2 ft deep. Larger plows are being used to invert soil to a depth of 6 ft. One extremely heavy disk plow is not only raised and lowered hydraulically, but a bypass valve permits disks to ride over rocks without damaging the plow.

Each of the machines discussed above has one or more hydraulic pumps and jacks. The jacks are fixed on the machines and are therefore not standard for interchangeability between machines. A large percentage of the machines with non-interchangeable hydraulic jacks are used on or with the larger track-type tractors.

The third classification of hydraulic power as applied to track-type tractors involves jacks that are interchangeable between two or more machines. These involve hydraulic applications where the jacks are built to the ASAE-SAE standard. This standard, adopted in March, 1949, covers the application of hydraulic remote controls to farm tractors and trailing-type farm implements. The standard is limited to farm tractors up to and including 35 dhp maximum. However, development of a similar standard for farm tractors with more than 35 dhp is nearly completed.

Interest in hydraulic controls on farm tractors was evident by the number of machines shown at the 1950 corn belt state fairs. All the hydraulic controls exhibited on farm tractors and implements did not involve the use of interchangeable jacks, but the trend to adopt the ASAE-SAE standard was very evident. It is impossible to tell now to what extent interchangeable jacks will be used on trailing-type farm implements. However, some of the more important applications will be discussed.

Moldboard, Disk and One-Way Stubble Plows. The hydraulic control shown on the four-bottom moldboard plow in Fig. 3 is built to the ASAE-SAE standard. If the hydraulic controls applied to plows have capacity to raise the plows out of the ground at the recommended speeds, then such controls will provide sufficient force to control most or all other farm pulled type machines. Tandem and single disks are also hydraulically controlled.

Pulled-Tpye Deep-Tillage Tools. A 16-ft blade is used to cultivate winter wheat stubble. Here again the standard hydraulic remote control can be used. Chisels, subsoilers, mole drainage machines, ditchers, and ridgers may also be controlled with a standard jack.

Levelers. Land levelers have been used for years on western irrigated farms. Fig. 4 shows an 8-ft leveler preparing land for pasture with an overhead irrigation system. This leveler is controlled with a standard hydraulic jack. Levelers are now being used in increasing numbers not only to prepare land to be irrigated but also to fill shallow depressions that will not permit satisfactory surface water runoff in high-rainfall areas.

Harvesting Machines. Harvesting machines, such as combines, corn pickers, and mowers are being equipped with standard hydraulic controls. Fig. 5 shows an experimental four-row corn picker made in Illinois. Two hydraulic jacks are used to steer the machine and control the elevation of the picker snouts. The jacks do not meet the ASAE-SAE standard but standard jacks could be used.

Tool Bars. An hydraulically controlled, direct-connected tool bar is shown in Fig. 6. It is controlled with a standard jack.

This is an abstract of a paper presented at the special session on agricultural hydraulics at the National Conference on Industrial Hydraulics at Chicago, Ill., October, 1950.

The author: FRANK P. HANSON, agricultural engineer, Caterpillar Tractor Co., Peoria, Ill.

The fourth classification of hydraulic power as applied to farm track-type tractors is hydraulic motors.

Hydraulic motors are not being used to any extent to power farm machines. Not many people can name even one farm implement that is powered in whole or part with hydraulic motors. Yet there are a few of these commercial and experimental machines, such as a mower, a sweet corn snapper, a plow and a spraying unit. Why are hydraulic motors not being used on more farm machines? Engineers give two reasons for this situation, namely, high first cost and low efficiency. Even though high cost and low efficiency have prevented the application of hydraulic motors to power farm implements, the future may present a different picture.

While the demand for transmitting farm tractor power by belts has decreased, the use of power-take-off-driven machines has increased. Transmitting the tractor engine power to operate the various moving parts of a farm implement may involve the use of many shafts, bearings, gears, clutches, universal joints, chains and belts, all of which cost money and result in power losses. Sometimes the cumulative power losses are rather high. When one considers that a 2000-rpm engine requires a transmission to transmit power to a power take-off shaft at 536 rpm and then another transmission to provide 2000-rpm rotating parts on a farm implement, it might be well to compare the resulting cost and efficiency factors with hydraulic motors. One rather important point concerning the application of hydraulic motors to power farm implements is that the hoses to connect the hydraulic pump on a tractor to a hydraulic motor on a farm implement allow a degree of flexibility of application not now found in conventional methods used to power farm implements.

Conserving Human Energy. Hydraulic controls conserve human energy. Energy required to operate a finger-tip hydraulic valve is nothing compared to the result when a hydraulic pump delivering 35 gpm at 1000 psi moves a piston 8 in in a 5-in-diameter jack. Any system of hand levers or wheel lifts will require more human energy to adjust a farm implement than merely operating a finger-tip valve that permits a hydraulic control to raise, lower or otherwise adjust a farm implement. Human energy is expensive; consequently it is economical to use it when and where it will produce the greatest benefit.

Hydraulic Controls Provide Two-Way Pressure. The second important convenience of hy- *(Continued on page 269)*

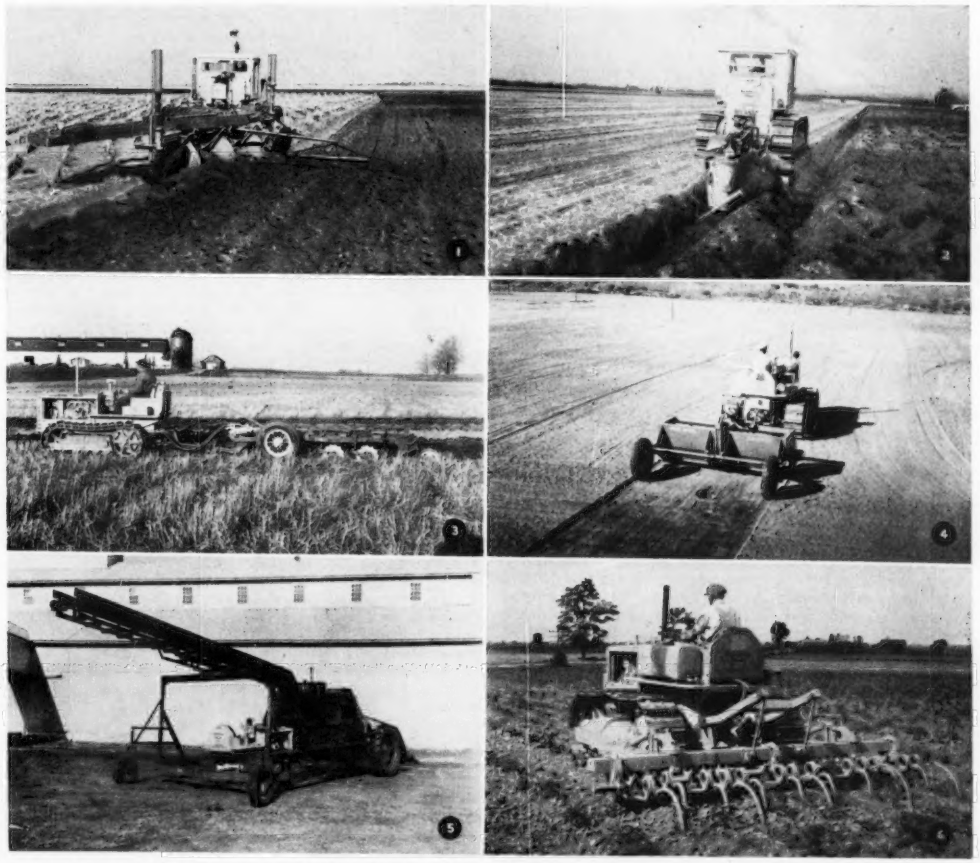

Fig. 1 Hydraulically controlled heavy-duty disk plow with 44-in-diameter disks • Fig. 2 Plowing bean land 2 ft deep with a special hydraulically controlled moldboard plow • Fig. 3 Using a hydraulic control made to ASAE-SAE standards to control a moldboard plow • Fig. 4 Hydraulically controlled land leveler preparing land for overhead irrigation • Fig. 5 Hydraulically controlled experimental 4-row corn picker • Fig. 6 Hydraulically controlled tool bar equipped with soil shank cultivators, cultivating potato ground 8 in deep

New Concepts in Side-Delivery Rakes

By Roy Bainer
FELLOW A.S.A.E.

DURING the past five years more new developments have occurred in the field of side-delivery rakes than in any other period of our farm machinery history. As early as 1894 (1)* side-delivery rakes were used for preparing windrows for mechanical hay loading. One of the earliest recorded manufacturers of this type of equipment was Chambers, Bearing, and Quinlan Co., of Decatur, Ill. Great interest in the side-delivery rake did not develop, however, until after the pickup baler, field chopper and pickup thresher were introduced for hay and such seed crops as beans, requiring a continuous, unbroken windrow for their satisfactory use. Since then, new rakes incorporating wheels, roller-bar assemblies, drag conveyor, and crowder principles have appeared.

The wheel rake, developed by Morrill of Tulare Co., Calif., in 1945, was first manufactured in 1946. It consists of a series of overlapping wheels (Fig. 1) carried on independent axles. The diameter of the wheels, including the coil-spring rake teeth, is 60 in. Adjustable coil springs, between a lever on the axle and the frame, carry part of the weight of each wheel. According to the manufacturer, the plane of the wheels makes an angle of 38 to 42 deg with the direction of travel. The rake actually checked was set for an angle of 56 deg. Each wheel rakes a width of approximately 1½ ft when operated at the normal angle. Rugged construction, plus the flexibility of the independently mounted wheels, makes possible high-speed raking over rough ground. The rake is well adapted to working over irrigation borders. Contact of the rake teeth with the ground furnishes the force required to turn the wheels. That the teeth sometimes pick up dirt and mix it with the hay has caused criticism from some growers.

The roller-bar type of rake, pioneered in this country by Johnson of Woodland, Calif., and now included in the Ferguson and Case line of rakes, had its origin in England. While visiting several English manufacturers of farm machinery in 1945, I found that the roller-bar rake, such as the Nicholson (Fig. 2), was common to most manufacturers of haying equipment. Recent correspondence with R. S. Foster of Nicholson and Sons of Newark, England, revealed that W. E. Martin of Stamford, England, was credited with the first introduction of this type in 1905. In the same year Martin applied for a U.S. patent, which was granted in 1906 (No. 818,899).

The Martin machine had most of the characteristics employed in the present-day rakes of the roller-bar type. The following statement is quoted directly from the Martin patent: "Hitherto such side-delivery rakes (teeth)† have been rotated or moved at right angles to the oblique position of the rakes, and owing to the forward motion of the machine, the rake did not deliver the crop rapidly to the side, but had a tendency to rake it forward, thus doing unnecessary work. In side-delivery rakes constructed according to my invention, the rakes (teeth) are caused to move in a circular path at right angles to the line of travel of the machine." His patent covered the use of both straight and curved teeth.

J. and J. C. Bamsford also of England hold U.S. Patents No. 1,047,147 and 1,195,172 issued in 1912 and 1916, respectively, covering rakes similar to the Martin. Later patents were also granted to Randall and Hitchcock of France covering similar ideas. The latter patents were assigned to the International Harvester Co. in 1928 and 1936, respectively.

The roller-bar rakes built by Johnson and Chase (Fig. 3) employ a 4-bar reel assembly, while the Ferguson uses 6 bars. These bars carrying the coil-spring rake teeth are attached, by suitable bearing mounts, to parallel plates or spiders at each end of the rake. The plate at the right end is rotated by a suitable drive from ground wheels (Johnson and Case) or from a power take-off connection on the tractor (Ferguson). The bars are constrained to rotate with the plates. Any point on the bar, therefore, must describe the same circle as the periphery of the spiders. As the reel revolves, each bar rotates within the bearing mounts to keep teeth in a vertical position at all times. When a bar approaches its lowest position, teeth come in contact with the hay, raking it for a short distance to be followed by the next bar. The bars have the appearance of rolling over each other as the reel is rotated. The reel component (motion of reel teeth with respect to the rake frame) makes an angle of approximately 70 deg with the forward travel in the Johnson and Case, and 100 deg in the Ferguson, as compared to 45 deg for a conventional cylinder-type rake.

The Curry rake was first conceived by Renault of Tulare Co., Calif. It consists of a pair of chains with 26-in cross flights attached at 23-in intervals (Fig. 4). Coil-spring rake teeth are attached to the flights at 4-in intervals to give a conveyor width of 27 in. The drag conveyor thus formed is operated at right angles to the direction of travel. Power for driving the chains is furnished by the power take-off. This rake has not gained the popularity shown either the wheel or roller-bar types. Its operation can be improved by making a rather simple modification to be pointed out later.

The McCall rake (Figs. 5 and 6) which is being developed by the McCall brothers of Riverside Co., Calif., is of the crowder type. It might even be compared to the curler used for windrowing immediately behind the cutter bar of a mower. The appealing feature is that it has no moving parts. It consists of a series of 30 curved teeth attached at 6-in intervals to the main frame by individual hinge mounts. Spring loading each tooth provides considerable flexibility. A narrow warped steel strap attached to the point of each tooth elevates the hay slightly and gives it a roll in the direction of the windrow. The angle of the teeth with the direction of travel is adjustable to give a raking width varying from 4 ft to 12 ft. For example, a 7-ft swath is made when the angle is 28 deg; at a 53-deg angle the rake covers a width of 12 ft.

The raking characteristics of the various machines can be readily determined by means of a vector analysis. A forward speed of 4 mph (352 fpm) is assumed in each instance. The tooth path is the resultant of the vectors representing forward motion and reel component. The reel component is actually the tooth path with respect to the direction of travel at zero forward motion. In the final analysis, all raking widths are standardized to a 7-ft swath.

An analysis of the Johnson roller-bar rake is shown in Fig. 7, A. At a forward speed of 352 fpm, the reel component has a value of 415 fpm. The reel component acts at an angle of 71 deg with the direction of travel. The resultant of the two vectors representing the forward motion and the reel component gives the direction and magnitude of the tooth path. From the diagram it will be noted that the average velocity of the tooth is 625 fpm and that the direction with respect to forward motion is 39 deg. It is quite evident from the diagram that the hay cannot move with the same velocity as the tooth. If it did, it would actually lead the rake. The bracketed portion of the tooth path represents the average hay velocity, which is 450 fpm. The distance a tooth moves in sweeping a 7-ft width equals $7 \div \sin 39 \text{ deg} = 11.1$ ft (A in Fig. 7, I).

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1950, as a contribution of the Power and Machinery Division.

The author: ROY BAINER, chairman, agricultural engineering division, University of California, Davis.

AUTHOR'S NOTE: The author wishes to acknowledge the helpful suggestions of R. A. Kepner and the assistance of his class of agricultural engineering students who made a study of the rakes as a special problem.

*Numbers in parentheses refer to the appended references.

†Added by writer to clarify meaning of "rakes."

The Case roller-bar rake (Fig. 7,B) is quite similar in operation to the Johnson rake. Because of the slight change in angle the tooth path makes with the forward motion, the teeth travel 10.5 ft in covering a 7-ft swath (B in Fig. 7,I).

The Ferguson roller-bar rake analyzed by Elliott (2) is included in this study because a 2-to-1 reduction was used in the power take-off speed from the tractor (Fig. 7, C). The reel component makes an angle of 100 deg with the forward motion, which gives it a slight rearward direction. The resulting tooth path acts at 65 deg with the forward travel. Because of this larger angle, the tooth travel amounts to 7.7 ft when raking a 7-ft width. The distance fore and aft between rake bars in the lowest position is 6 in as compared to 10 in for the other two rakes of this type. The closer spacing should result in smoother action on the hay.

For comparison, a conventional side-delivery rake (Fig. 7, D) was included in the study. All rakes of this type have similar characteristics. A Case 4-bar machine was the example used. As the reel is mounted in the frame at an angle of 45 deg, the reel component makes an angle of 45 deg with the direction of travel. The resulting tooth path makes an angle of 24 deg with the forward motion at an average tooth velocity of 690 fpm. The average hay velocity is shown to be 390 fpm, by the bracketed section of the tooth path. The larger difference between the tooth velocity and the hay velocity accounts for the lower efficiency of moving the hay. The distance traveled by a tooth in raking a 7-ft swath is 17.2 ft (D in Fig. 7, I). This is 63.8 per cent farther than the distance covered by a tooth in Case's new roller-bar rake.

The Morrill wheel rake cannot be analyzed as straightfor-

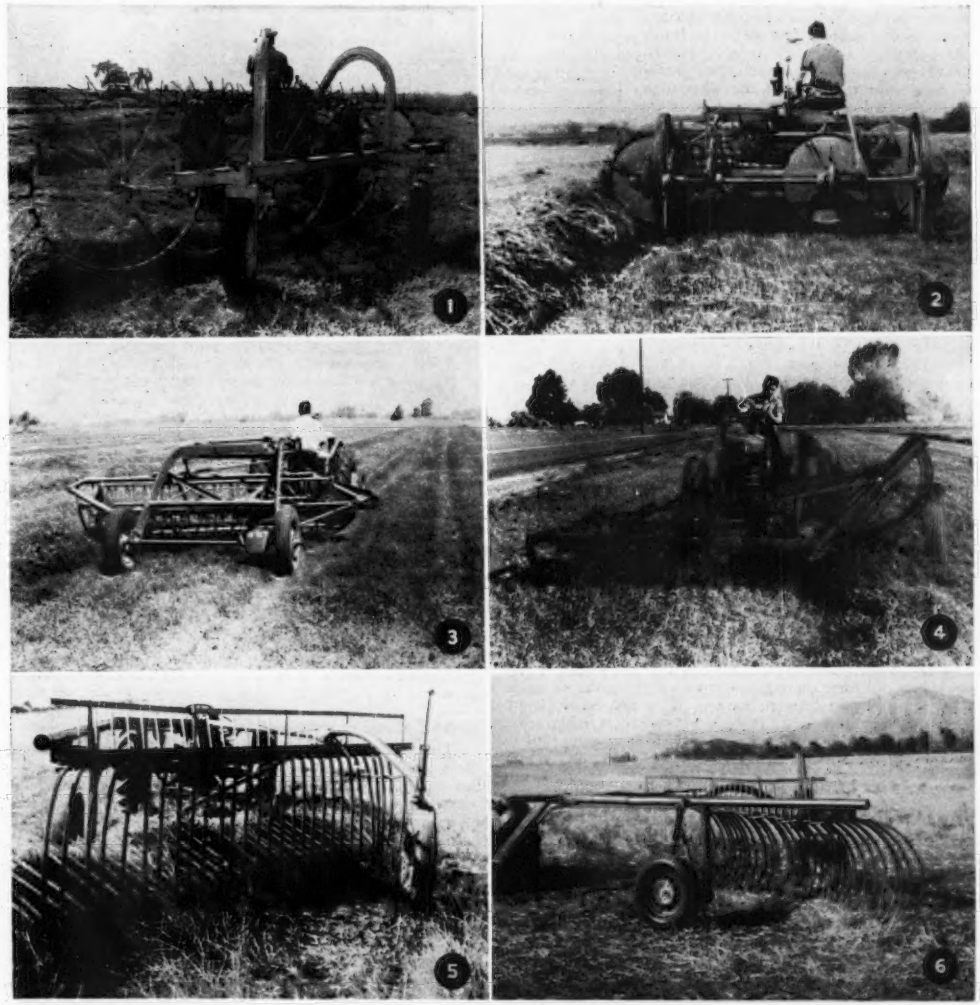

Fig. 1 Morrill side-delivery rake. Hay is raked by overlapping wheels driven by ground contact • Fig. 2 Nicholson roller-bar rake manufactured at Newark, England, and patterned after the Martin rake • Fig. 3 J. I. Case roller-bar rake • Fig. 4 Curry drag-conveyor rake mounted on the front end of a tractor • Fig. 5 Rear view of McCall rake • Fig. 6 Side view of McCall rake. Note the short steel strap attached to the point of each main rake tooth which elevates the hay slightly and gives it a roll in the direction of the windrow

wardly as the others because its rake wheel is driven by the teeth in contact with the ground, and the teeth do not have parallel motion but rotate about the wheel center. At least part of the raking, then, is done with the face of the wheel at some point above the ground level. The radius of the wheel to the tip of the teeth is 30 in. If the layer of the hay in contact with the wheel is 12 in thick, then the average contact point on the wheel would be at a radius of 24 in. This dimension was assumed in the analysis as shown in Fig. 7, E. The angle between the plane of the wheels and the forward motion is adjustable. The setting on the rake studied was 124 deg. Actually, the tip of the tooth in contact with the ground would have a velocity relative to the frame ($352 \div \cos 56 \text{ deg} = 630$ fpm. However, since it was assumed that the raking would be done with a section of the wheel 6 in above this point, reel component amounts to 80 per cent of 630, or 504 fpm. Under these conditions the angle between the tooth path and the direction of travel amounts to 80 deg. The distance traveled by this point is 7.1 ft for a 7-ft swath (E in Fig. 7, I).

The results show that it made little difference whether the effective raking point was taken at the rim or at a short distance toward the center.

The McCall rake moves the hay by crowding or blading it over. The shape of the points and the warped-steel straps are such that the hay is rolled toward the windrow. From the diagram (Fig. 7, F) it will be seen that the component along the axis of the rake teeth has a value of 400 fpm, when set for an angle of 152 deg with the forward motion. The hay is moved laterally at a theoretical velocity of 185 fpm. This is on the assumption that the hay is held from moving ahead by contact with the stubble.

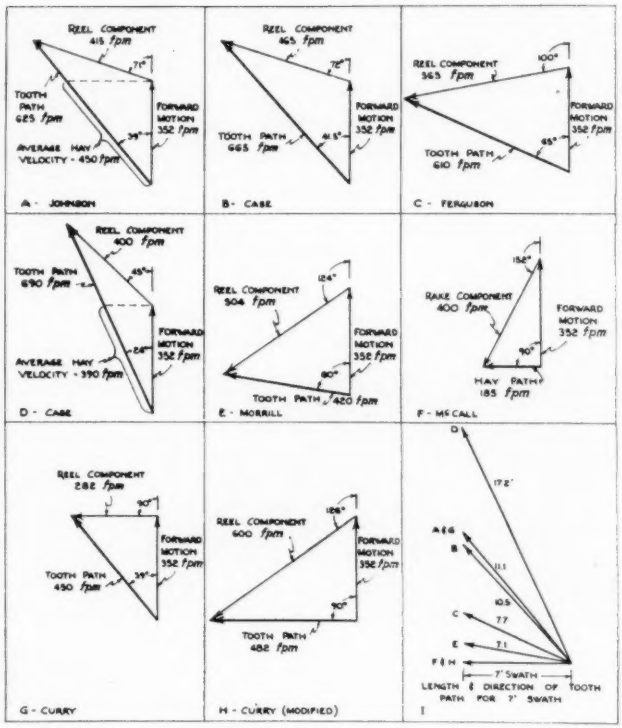

Fig. 7 Vector analysis of various rakes studied. The length and direction of the tooth path for each rake, for a 7-ft swath, is shown in the lower right-hand corner

The resultant tooth path for the Curry rake (Fig. 7, G) makes an angle of 39 deg with the forward motion. The length of the tooth travel for a 7-ft swath amounts to 11.1 ft. Gunn‡ suggested operating the drag conveyor at some rearward angle with an increase in chain speed, thereby reducing the distance the hay would have to travel during the raking operation. Many combinations are possible. The one chosen is shown in Fig. 7, H. If the raking section is set at 126 deg with the direction of travel and the reel component is increased to 600 fpm, the resulting tooth path makes an angle of 90 deg with the forward motion. This reduces the tooth travel to the minimum of 7 ft for a 7-ft swath (H in Fig. 7, I). The resulting tooth speed would be 482 fpm as compared to 450 fpm for the original arrangement. The raking unit would have to be lengthened to 8.66 ft to give the same raking width as before.

It is evident from this study that there are several distinct variations in the performance of side-delivery rakes now available. In general, the average velocity of the hay is less than the speed of the tooth. As the angle between the tooth path and the forward motion increases, the length of the tooth path decreases, resulting in a minimum value when a 90-deg angle is reached. Rakes with rearward reel components are more positive in action in that the hay velocity will more nearly approach the rake-tooth velocity.

The McCall and the conventional side-delivery rakes have the lowest average hay velocity. However, because of the small angle between the tooth path and forward motion, the distance traveled by the hay is the greatest for the conventional rake.

A series of short contacts with the reel teeth moves the hay. The extra distance it travels when in proper condition for raking is not too serious from a leaf shatter standpoint. On the other hand, if a dry product like some of the seed crops is to be raked, this extra distance the material travels may result in large shatter losses.

The effectiveness of the conveyor rake can be materially improved by introducing a rearward motion to the reel component, resulting in a tooth path which makes an angle of 90 deg with the forward motion.

The McCall rake depends upon the stubble and weight of the windrow to hold the hay against the rake teeth so that it can be rolled into a windrow. The hay path is no doubt greater than the theoretical amount indicated in the analysis of the rake. Since this rake is new, tests under various field conditions are needed to determine its full characteristics.

The graphical analyses presented must not be considered final as to the relative merits of the various rakes studied. Detailed field studies are needed to determine the actual length of the hay path, the tendency to tangle windrows, the degree to which the field is raked clean, the shatter losses, and other factors such as the relative speeds of operation.

‡Gunn, J. T., assistant specialist in the experiment station, University of California.

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Discussion by Wm. Vutz*

MEMBER A.S.A.E.

IT IS much to Professor Bainer's credit to have made an attempt at systematic analysis of the action of the various new rakes appearing in the field. Theoretical investigations of this type are very necessary; as a matter of fact, ideally they should precede any design work. If in this case the work could be coupled with conclusions on field performance, a notable example of the contributions that experiment stations can make in machinery development would be had.

It would be highly erroneous, as Mr. Bainer points out, to base any evaluation of a rake on these elementary considerations.

A common observation on rakes, presented by type D (Fig. 7), is the fact that, instead of simply being pushed ahead and to the left, the hay is actually rolled into a windrow. The formative stages of a windrow actually represent a hollow cylinder composed of a spirally wound ribbon of hay. With correct windrowing practices, it will be found that the butt ends of the stems radiate outwardly from the finished windrow. As the magnitude of the reel component in the diagram is reduced, a progressively tighter windrow is made. Such tighter windrows are often preferred by men operating pickup balers; they are, however, not conducive of even drying in the windrow. A good deal of leaf loss is due to raking the hay in a state of finished or near-finished drying, in which case leaf loss is largely a function of the amount of compression the rake exerts on the windrow in the formative stage.

With increasing angle between forward motion and reel component, there is a tendency to tight packing of the windrow, unless proper balance between forward motion and reel component to suit the exact requirement of the hay under the given circumstances is had. In extreme cases, no spiral windrow in the accepted sense is made, but the hay is rather pushed into a long heap without consistent arrangement of the material throughout the cross section of the windrow.

Such factors as tooth spacing, frequency of tooth contact with the ground — tooth shape even — have considerable bearing on the quality of the work done. As the next step in this investigation, I would suggest a set of diagrams, corresponding to those in Mr. Bainer's series A to H (Fig. 7), giving the pattern of tooth incidence with the ground as based on the given tooth spacing.

Due to the highly complex nature of the field process of raking, a very interesting and fascinating correlation of theoretical analysis and actual field performance would seem to be in store for the individual or agency ready to undertake such a project. That there is a very serious need for systematic study of side-delivery rakes operated with present-day tractors, generally at fairly high rates of speed, most engineers designing rakes, I believe, will readily be in agreement. Such work should preferably extend over the various geographical sections of the country; it could well be a cooperative project for a western, midwestern and an eastern experiment station.

*WM. VUTZ, chief engineer, New Idea, Div. Avco Mfg. Corp., Coldwater, Ohio.

Idaho Potato Harvesters

(Continued from page 263)

The farmer building the original machine spent $1,200 for material in addition to the engine and units available on the farm. He spent six weeks making the machine with the help of the agricultural engineer.

The advantage of this machine to the farmer was that potato harvesting can now be a family affair. He is not dependent upon itinerant workers. The wife drove the tractor; one man drove the bulk truck, and the farmer, with the help of four neighbor girls, operated the harvester. The girls operated the machine during the period the farmer spent storing potatoes in the farm cellar. Potatoes can be put into the cellar for an out-of-pocket cost of 10 cents per sack. In addition, at the end of each day's work the potatoes dug are in the cellar. There are no potatoes left in the field to get wet or freeze.

Hydraulic Power in Farming

(Continued from page 265)

draulic farm implement controls is associated with two-way pressure. A double-acting jack not only provides a force to lift a bulldozer, plow or loader, but it also provides an opposite force to cause implements to function satisfactorily when they would not do so with hand or wheel controls.

Multiple Hydraulic Controls. A third convenience results with the use of multiple controls. Some farm implements can not be controlled with one jack; therefore, a multiple valve will permit using two or more jacks.

Operator Comfort. A fourth convenience may be classed as operator comfort. It wasn't many years ago when a farmer riding a spiketooth harrow cart was considered lazy—he just wasn't a real he-man if he resorted to riding instead of walking. Today tractor operator comfort is being given special attention. Canopies, cabs, hoods, etc., are used to protect the operator from extremes of high and low temperatures, rain and snow, dust and noises. When the tractor operator can control farm implements with finger-tip hydraulic controls within easy reach, he is given a real comfort feature.

Fast and Slow Fractional Adjustments. Fast and slow fractional implement adjustment is the fifth convenience resulting from the use of hydraulic implement controls. When a plow begins to sink out of sight in a soft spot, it is desirable to raise the plow quickly without stopping or stalling the tractor engine. Hydraulic controls permit the operator to do just that. When a combine header is set too high, it misses the lower pods on soybean plants, and if too low, the cutter bar will dig into the ground. Fractional adjustments of a header bar are often needed to obtain satisfactory results.

Operator Safety Extremely Important. A sixth convenience of hydraulic implement controls pertains to operator safety. When it is necessary for an operator to reach for levers on an implement or stop and get off the tractor to adjust implements, the possibilities of accidents are manyfold as compared to adjusting a farm implement by merely moving a conveniently located lever. Repetitive hand adjustments that waste time and energy cause operators to become careless, especially when tempers are on edge. A slight delay in operating a hand lever on a mower, or even pulling a rope for a wheel lift, may result in a clogged machine that necessitates hand cleaning. All such hand-cleaning operations are promoters of accidents.

More Work per Hour. The seventh convenience covers less machine "down time." One does not combine when the grain is wet with dew or bale hay in the field when it rains. Timeliness is extremely important for many farming operations. The uncontrollable lag in adjusting machines by levers or wheel lifts can result in a stalled machine that may require many minutes to straighten out. Those lost minutes can be costly. Hydraulic implement controls can insure more continuous operation of farm implements when it is most timely that they be working.

Power Controls More Dependable. The eighth convenience of hydraulically ccontrolled farm implements promotes quality of work done. An operator desires to leave a sod waterway when plowing a field. That means the plow must be raised and lowered at the right time, otherwise the waterway will be too wide or too narrow in places. If the hand or wheel lifting arrangement doesn't operate smoothly, perhaps the operator will be inclined to get careless or even give up attempting to leave a grassed waterway. If the hand lever control is too difficult to operate, perhaps the operator will not lower the cutter when crossing a low spot, such as a deadfurrow, thereby resulting in losses when combining soybeans. The average human being can't be subjected to many inconveniences without resorting to short cuts, and these often result in not doing a job the way he knows it should be done. Therefore, because of the ease and dependability of using hydraulic controls, the operator is encouraged to do what he knows he should do.

The Effect of Circular Perforations on Flow into Subsurface Drain Tubes

Part II. EXPERIMENTS AND RESULTS

By G. O. Schwab and Don Kirkham
MEMBER A.S.A.E.

IN PART I (1)* of this paper, it was shown that Q_g, the quantity of flow entering a unit length of perforated drain tube per unit time, when the perforations are considered to be spherical openings (sinks), is

$$Q_g = \frac{2\pi K (d + t - r_w)}{C + \log_e (2d/r_w)} \quad . \quad . \quad . \quad [1]$$

whereas, when the perforations are assumed to be circular plate-shaped openings the flow Q is

$$Q = \frac{4K (d + t - r_w)}{C + \log_e (2d/r_w)} \quad . \quad . \quad . \quad . \quad . \quad [2]$$

If the drain tube is completely porous (open), the flow Q_o is

$$Q_o = \frac{2\pi K (d + t - r_w)}{\log_e (2d/r_w)} \quad . \quad . \quad . \quad . \quad [3]$$

Equation [2] should correspond to observed field conditions more closely than equation [1]. The completely porous drain tube of equation [3] is one which in practice is embedded in gravel. Symbols in equations [1], [2], and [3] are: K=soil permeability, d=drain tube depth to center of drain tube, t=thickness of surface water, r_w=drain-tube radius, C=a rather involved constant defined by equation [7] of Part I (1) of this paper, depending on the radius and spacing of perforations and on the drain-tube radius. The Q's in the above equations will be in cubic feet per day per foot of drain-tube length, if K is in feet per day and the other symbols are in feet.

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The authors: G. O. SCHWAB and DON KIRKHAM, respectively, research associate in agricultural engineering and research professor of agronomy and professor of physics, Iowa Agricultural Experiment Station, Ames.

AUTHORS' NOTE: The authors wish to acknowledge valuable discussion with Dr. J. F. Carlson of the physics department, Iowa State College, in connection with Parts I and II of this paper.

*Numbers in parentheses refer to the appended references.

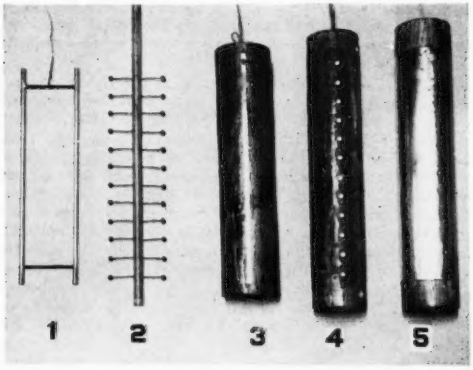

Fig. 1 Drain-tube models used in the electric analogue for seepage flow into drain-tube perforations

ELECTRIC ANALOGUE

Equations [1], [2], and [3] were verified using electric models to stimulate seepage flow. Electric models or analogues are based on the observation that Ohm's law and Darcy's law are analogous. Thus, seepage flow corresponds to electric current, hydraulic gradient to voltage gradient, soil permeability to specific electrical conductivity, impermeable boundaries to insulators, and surfaces of equal hydraulic head to conductors at constant potential. A principal advantage of the electric analogue is that uniform conductivity for the flow medium is easily achieved. This is not the case in a field or laboratory test, in which more or less puddled soil is necessarily used. With soil it is difficult, if not impossible, to obtain uniform water permeability in a reasonable time. In the field, many years may elapse before soil in a tile trench assumes a condition approaching that existing before excavation. Sand models obviate puddling but are less flexible than electric models. Childs (2) has used two-dimensional electric analogues in the study of some agricultural drainage problems. Frevert (3) recently developed a three-dimensional electric analogue for the study of measurement of soil permeability; this apparatus in modified form has been used by Frevert and Kirkham (4), Van Bavel and Kirkham (5), and by Luthin and Kirkham (6). As the present problem was a three-dimensional one, some of Frevert's apparatus has again been used in these tests.

MODELS

Fig. 1 shows five electric models, all representing one-foot lengths of drain tubes used in this study. Only one-foot lengths (or some other convenient length) need be considered since the flow is the same into each unit length of drain tube, excluding of course the case that successive lengths have differing arrangements of perforations. Models 1 and 2 were designed on the assumption that the perforations are equivalent to spherical sinks, model 1 being a special case of model 2. Model 2 consists of two lines of spherical electrodes supported rigidly to a lucite tube by insulated copper wire. The wire, aside from holding the metal balls in place, serves to conduct (through the center of the lucite tube) electric current from the balls to an external voltage supply. The insulated wires and the lucite tube are kept small in order to stimulate more nearly the assumed condition that the size of the wires and lucite tube should be infinitesimal. Model 1 represents a limiting case of model 2, the case when the distance between the centers of the spherical sinks (dimensions a of Fig. 2 in Part I) is zero. Model 1 thus consists merely of two parallel, cylindrical electrodes held apart rigidly.

Models 3 and 4 correspond to models 1 and 2, respectively, except that circular plate-shaped electrodes replace the spheres, and that the flat electrodes are set in a cylindrical shellaced wooden block, simulating a drain tube, rather than being suspended in space as in models 1 and 2. Model 3 corresponds to a drain tube slotted longitudinally on diametrally opposite sides.

Model 5 represents a completely pervious drain tube, that is, it represents, practically speaking, a drain tube embedded in gravel. For this case, since now the whole drain-tube surface is at equal hydraulic head, the one-foot-long model becomes a cylindrical electrode. All the one-foot-long models are mounted in turn in a tank assembly as shown in Fig. 2. The side walls of the tank assembly are dielectric materials, the

walls here simulating the conceivable field condition that thin strips of impermeable material could be placed at locations one foot apart and perpendicular to a drain tube without disturbing the flow. The bottom of the tank assembly is a sheet of copper; the top and ends are open. If the top and ends were made of dielectric sheets, and if the tank assembly were filled with electrolyte and turned upside down, then the copper sheet, if held at a certain voltage, would represent the water table, the face opposite the copper sheet would correspond to an impermeable layer in the soil, and the ends of the tank would correspond to impermeable end boundaries. Since in the present case, a horizontal water table is under consideration, most of the flow per unit time enters the drain from a relatively small volume of soil above the drain tube (7). Therefore, what happens at the ends of the tank (if no voltages are applied at the ends) is immaterial. The fact that the ends of the model would have little effect was made use of. Instead of designing a new tank, the unit shown in Fig. 2 was placed in a stock-watering tank (Fig. 3). The assembly is placed in the larger tank with the copper side down. The air *above* the water-filled tank now represents an impervious layer *beneath* the drain tube. In the electric analogue the model may be upside down because electric force, not gravity, causes the flow. The stock-watering tank with tank assembly and external electrical equipment is shown in Fig. 3. Tap water serves as electrolyte.

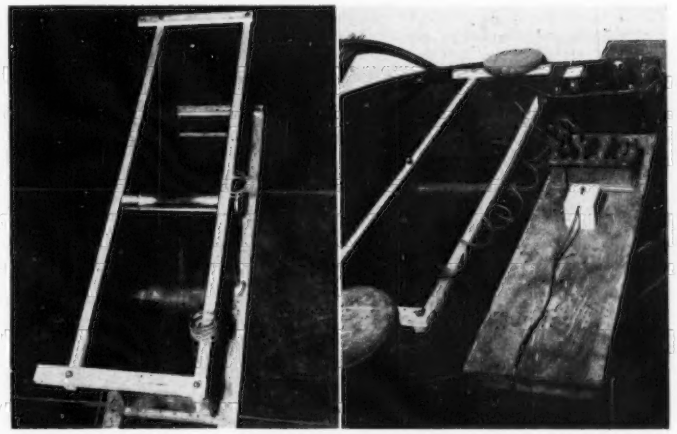

Fig. 2 *(Left)* Tank assembly for holding drain-tube models shown in Fig. 1 • Fig. 3 *(Right)* Stock water tank, tank assembly and drain tube, and external electrical equipment for model tests of theoretical equations: (1) transformer, (2) Wheatstone bridge, (3) electronic voltmeter, and (4) tank assembly of Fig. 2

In the electric anlogue it is not necessary, according to Frevert and Kirkham (4) to measure both voltage and current. One need only measure the ratio of these quantities. That is, one need only measure the resistance between the electrodes representing the drain-tube perforations and the copper electrode representing the water table. A Wheatstone bridge is used for making this measurement, an electronic voltmeter being used to balance the circuit. A circuit diagram for the Wheatstone bridge and other equipment is shown in Fig. 4.

PROCEDURE

In considering the effect of drain-tube perforations on flow it is convenient to use the ratios Q_s/Q_o and Q/Q_o rather than the values of Q_s and Q_o alone. Theoretically, these ratios are (see equations [1], [2], and [3])

$$\frac{Q_s}{Q_o} = \frac{\log_e (2d/r_w)}{C + \log_e (2d/r_w)} \quad . \quad . \quad . \quad . \quad [4]$$

and

$$\frac{Q}{Q_o} = \frac{2}{\pi} \frac{\log_e (2d/r_w)}{C + \log_e (2d/r_w)} \quad . \quad . \quad . \quad . \quad [5]$$

It is likewise convenient to use these ratios for experimental tests rather than equations [1], [2], and [3], individually. One sees this as follows: In the electric case $(d+t-r_w)$ becomes the applied voltage and Q_s the current so that $(d+t-r_w)/Q_s$ corresponds electrically to a resistance which can be denoted R_s—with similar values R and R_o corresponding to Q and Q_o. Thus, if the specific electrical conductivity of the tank water stays constant throughout all tests, one sees that the expressions

$$Q_s/Q_o = R_o/R_s \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [6]$$

and

$$Q/Q_o = R_o/R \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [7]$$

should be identities if the theory is correct. To test equations [6] and [7], the right-hand sides are determined by measuring R_o, R_s, and R (R_o, R_s, and R are R_4 of Fig. 4) and calculating the ratios R_o/R_s and R_o/R. The left-hand sides of equations [6] and [7] are obtained by substituting in the right-hand sides of equations [4] and [5] numerical values of d and r_w into the logarithmic terms, and r_w, r_p, a, and m into the constant C as defined in equation [7] of Part I (1), and performing the calculations.

When R and R_s were measured, the two lines of plate and sphere-electrodes were kept in a horizontal plane even though the theory (and tests) showed that the orientation of this plane would be immaterial. In order to minimize changes in specific conductivity of the electrolyte due to temperature changes the tank was kept in a constant-temperature room. Alternating current was used in the bridge circuit to prevent polarization. Even so, coatings would form on some of the electrodes and cause a slight increase in resistance. This increase in resistance was more pronounced for the smaller electrodes. To remove any coatings, electrodes of the models were cleaned with steel wool before each reading. It was observed that slight contamination as from grease on fingers could also result in considerable error in measurements.

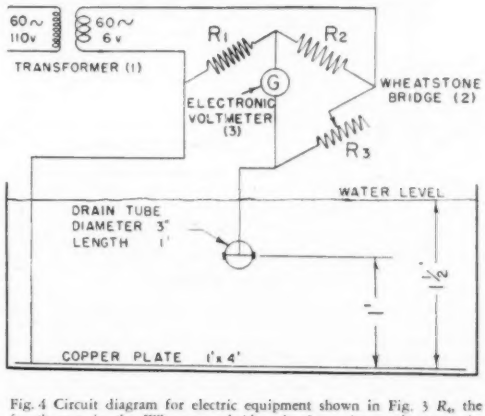

Fig. 4 Circuit diagram for electric equipment shown in Fig. 3 R_s, the fourth arm in the Wheatstone bridge, is the resistance between the drain tube and the copper plate. Numbers in parentheses correspond to the numbers in Fig. 3

RESULTS

Measured and theoretical values for sphere- and plate-electrodes are presented in Fig. 5. Although the theoretical curves are somewhat higher, generally, than the experimental points, it is felt that the results serve to verify the theory and that therefore the theoretical equations can be used with confidence to calculate rather extensive results for practical use. These results, representing 672 indpendent calculations of the right-hand member of equation [5], are brought together in Figs. 6 and 7. For plates the theoretical curves, as shown in Fig. 5, are low at zero spacing of perforations compared to experimental values. In noting these low values one should remember that the theoretical curves for plates are not valid at spacings less than 2 to 3 in (see Part I (1), calculations above equation [13]). Although the theory begins to break down at narrow spacings, equation [5] has been used as an approximation to obtain the curves shown in Figs. 6 and 7 for all spacings. In practice it is doubtful if such close spacings will be used.

Fig. 6 presents the data in terms of spacing, and Fig. 7 in terms of holes per foot. The compact presentation of data in Fig. 7, which comprises all results, stems from the observation in Fig. 6 that equal numbers of holes per foot yield, very nearly, the same total flow per foot regardless of the number of rows of holes.† The data for the curves in Fig. 7, except for values of Q/Q_o for 2 and 48 holes per foot, are average values of Q/Q_o for $m=2$, 4, and 8. For 2 holes per foot Q/Q_o is the average for $m=2$ and 4, and for 48 holes per foot it is the average for $m=4$ and 8.

Curves for the absolute values of Q are given in Fig. 8. The curves were obtained from those of Fig. 7 by multiplication of the ordinates by $Q_o=2\pi K\,(d+t-r_w)/\log_e(2d/r_w)$. In the calculations K is taken as one foot per day, t is taken equal to zero, and r_w is omitted from the expression $(d+t-r_w)$. The term r_w is omitted since it is assumed that here the drains are running about half full, rather than full.

It is of interest to compare flow into a drain tube having circular perforations, with flow into the more conventional tube having cracks between the unit lengths of impermeable drain pipe. Kirkham (8) has shown in the latter case that if one takes the flow into the completely pervious drain tube as 1.000, then the flow into a 4-ft-deep, 6-in-diameter drain tube

†This observation is not quite true for large diameter drains. For example, for the extreme case of a 12-in diameter drain at one-foot depth with 24 one-half-inch holes per foot, the value of Q/Q_o for 2 rows of holes is 0.303, for 4 rows of holes 0.388, and for 8 rows of holes 0.404. The average value here is 0.365 and the deviation from the average value is, therefore, approximately (0.365—0.303) 100=6.2 per cent.

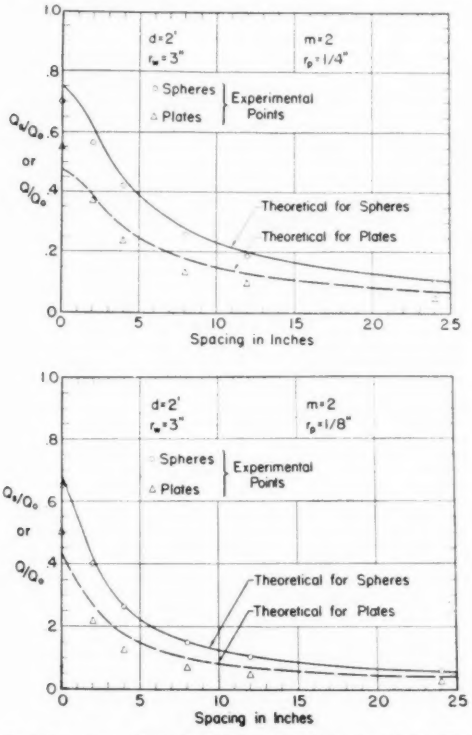

Fig. 5 Comparison of experimental and theoretical values of the effect of perforations on drain-tube performance. Solid lines are theoretical curves obtained on the assumption that drain-tube perforations are equivalent to spherical openings in the soil. Dashed lines are theoretical curves based on the assumption that the perforations are flat, circular openings in drain tubes. Symbols are: d=depth of drain, r_w=radius of drain, r_p=radius of perforations, m=number of longitudinal rows of perforations, Q/Q_o=ratio of the flow into a perforated tube to the flow into an open (gravel-embedded) tube, and Q_s/Q_o=ratio of the flow into spherical openings to the flow into an open tube

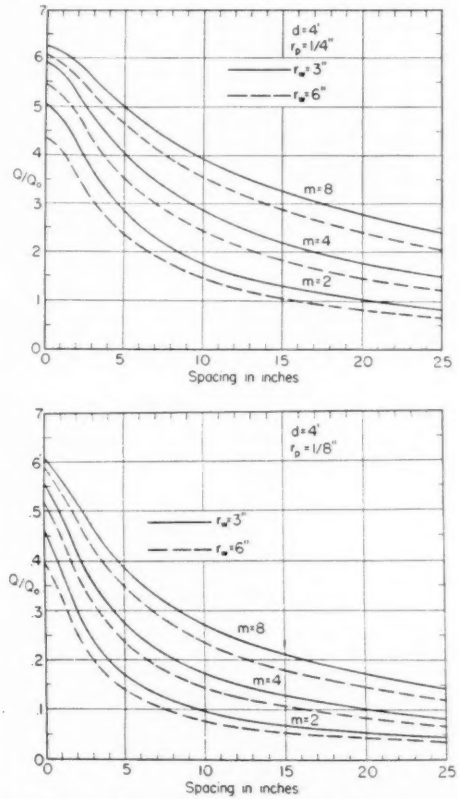

Fig. 6 Theoretical values of Q/Q_o versus spacing of perforations for drains 4 ft deep. The ratio Q/Q_o compares the flow into a perforated tube with that into a completely open (gravel-embedded) tube. The soil is assumed to have uniform permeability, and to be water-saturated to the surface. There can also be ponded water. For meaning of symbols see Fig. 5

consisting of a series of one-foot-long impermeable lengths is, for crack widths between the one-foot lengths of ⅛-, ¼-, and ½-in, 0.433, 0.485, and 0.555, respectively. For the same conditions, except for a depth of 2 ft, the values are 0.379, 0.430, and 0.491. The senior author of the present paper checked Kirkham's latter three values using the electric-analogue method. The experimental and theoretical values were in agreement to less than 3 per cent.

CONCLUSIONS

From Fig. 7 a number of practical conclusions can be listed. These conclusions, it must be remembered, are valid only for soils of uniform permeability, water-saturated to the surface, and with or without surface water. When reference is made in the list below to a drain tube embedded in gravel, it is assumed that the gravel layer is thin; that is, that the effective increase in drain size due to gravel is negligible; and that the flow into such a gravel-embedded drain tube is the same as that into a completely porous drain.

1 Flow into perforated drain tubes in soils is much smaller than flow into the same tubes embedded in gravel. For 6-in-diameter drains at 4-ft depth with two ½-in-diameter holes per foot, the use of gravel would increase the seepage rate, based on values taken from the lower left-hand diagram of Fig. 7, by an amount $(Q_o-Q)/Q=(1-Q/Q_o)/(Q/Q_o)=(1-0.153)/(0.153)=554$ per cent; and for ten ½-in-diameter holes per foot, $(1-0.402)/(0.402)=149$ per cent.

2 For four holes per foot or less the flow is roughly proportional to the number of holes per foot. Three holes per foot will yield slightly less than three times as much flow as one hole per foot.

3 Above four holes per foot, additional holes do not result in proportionately increased flow, but the increase in flow is rapid up to about 10 holes per foot.

4 Doubling the diameter of perforations (although the area of open space is thereby quadrupled) does not double the flow, but does result in an appreciable increase. For 6-in-diameter drains at 4-ft depth, an increase in hole size from ¼-in diameter to ½-in diameter, increases the flow, for four holes per foot (again reading from the lower left-hand diagram of Fig. 7) $(0.251-0.149)/(0.149)=68$ per cent, and for 10 holes per foot 46 per cent.

5 The effect of perforations in reducing flow is somewhat less marked at large depths than at shallow depths. For 6-in-diameter drains, having four ½-in-diameter holes per foot, the reduction (compared with gravel) is 75 per cent at a 4-ft depth and 72 per cent at an 8-ft depth.

6 Although, other quantities being equal, large-size drains yield more flow than small drains (Fig. 8), nevertheless, the relative increase in flow to be gained by embedding tubes in gravel is greater for larger size drains than for smaller. For example, in the case of drain tubes at 4-ft depth, having ½-in-diameter holes, the relative increases for 12-, 6-, 4-, and 2-in-diameter drains are, respectively, for two holes per foot, 700, 554, 488, and 403 per cent; and for 10 holes per foot 182, 149, 134, and 114 per cent.

7 The seepage rate into tile drains with various crack spacings can be compared with perforated drain tubes of the same diameter and depth. For 6-in diameter drains at a depth of 4-ft, crack spacings of ⅛-, ¼-, and ½-in per foot of drain length yield the same seepage rate as 12, 17, and 31 ½-in

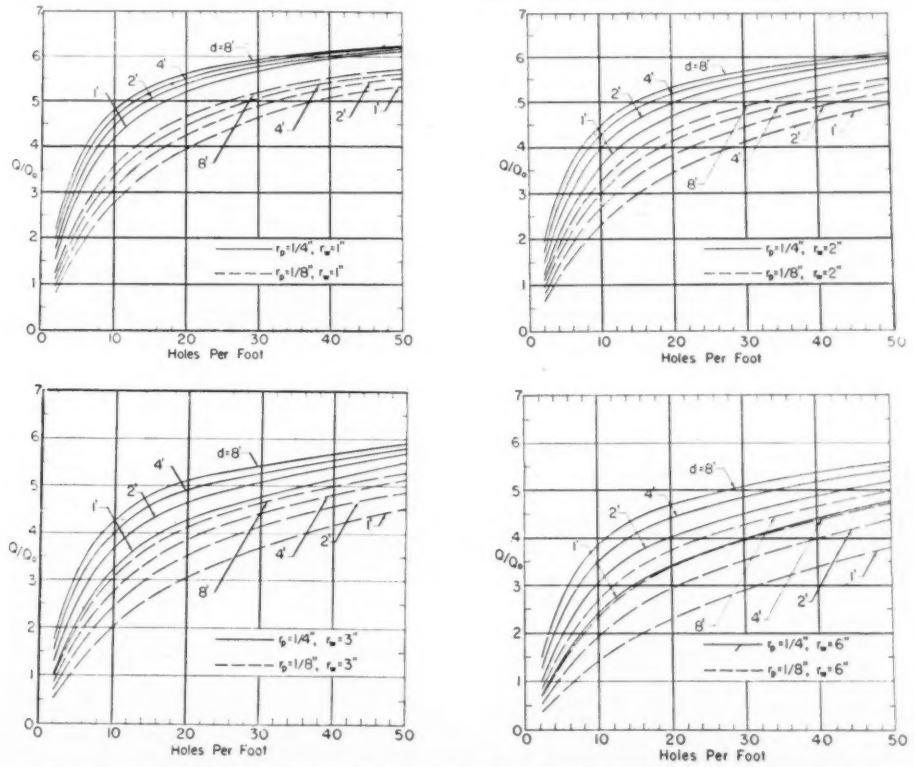

Fig. 7 Theoretical values of Q/Q_o versus number of perforations per foot of drain tube. For meaning of symbols see Fig. 5

holes per foot, respectively. If the holes are ¼ in in diameter, 25, 36, and 75 holes per foot are required. The calculations in this paragraph were carried out for the case of eight longitudinal rows of holes, but the results would be about the same for other numbers of longitudinal rows.

SUMMARY

Theoretical equations, derived in Part I (1), which give the effect of drain-tube perforations on drain-tube performance in water-saturated soil under a horizontal water table (the case of ponded water being included) were verified experimentally using electric models to simulate the seepage flow conditions. The experimental results confirmed the theory.

The theory having been established, values of the seepage rate Q per unit length of drain tube and of the ratio Q/Q_o (Q_o referring to a drain tube embedded in gravel) were computed for 2, 4, 6, and 12-in-diameter drain tubes; for 2, 4, and 8 rows of holes; for ¼- and ½-in-diameter perforations; for depths of 1, 2, 4, and 8 ft; and for 2 to 50 holes per foot. Figs. 7 and 8 in the body of this paper epitomize the results. Fig. 7 compares the flow of perforated drain tubes with completely open (gravel-embedded) tubes, and Fig. 8 presents absolute values of the seepage rate Q. Specific numerical examples are given in the conclusions.

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Progress Report of the Washington Farm Electrification Committee, 1950, by W. E. Matson and J. Roberts. This 26th annual report covers poultry brooding studies and dairy calf housing.

Fertilizer Application. Proceedings of the 26th Annual Meeting, National Joint Committee on Fertilizer Application (Washington, D.C.). Includes copies of papers presented on the fertilizer application program sponsored jointly by the Committee and the Power and Machinery Division at the ASAE Winter Meeting at Chicago, December, 1950.

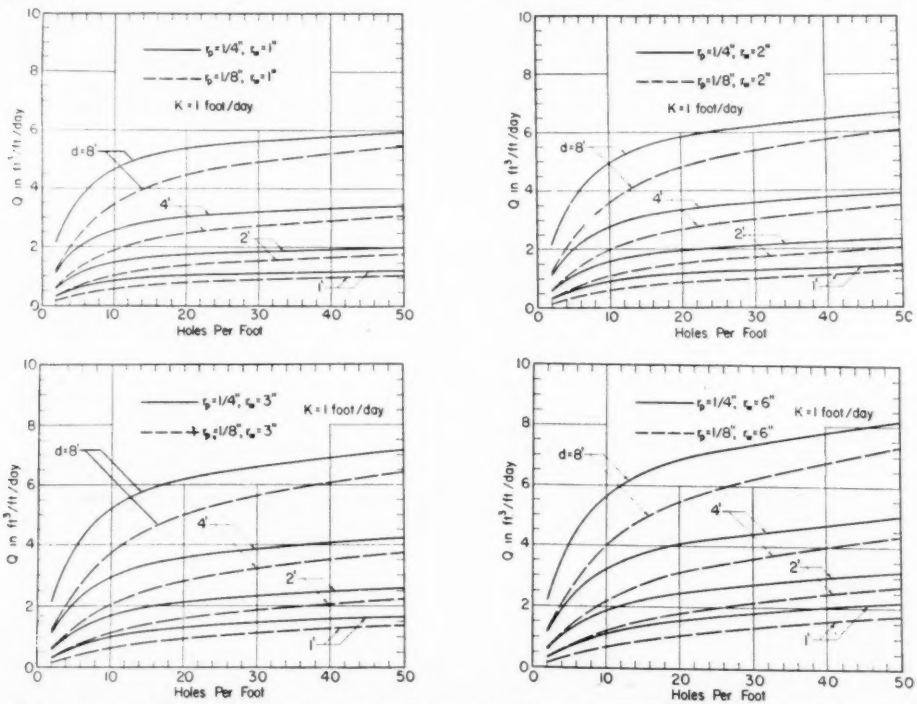


Fig. 8 Flow, Q, into perforated drain tubes in cubic feet per day per foot of length for a water-saturated soil of uniform permeability for which K = one foot per day. If soil permeability is 2 ft per day, multiply the ordinates by 2, etc. For meaning of symbols see Fig. 5

Wind Damage to Farm Buildings

By Merle L. Esmay and Henry Giese
MEMBER A.S.A.E. FELLOW A.S.A.E.

THE belief that much of the extravagant farm building damage is preventable has stimulated the continuance for twenty years of a project of the Iowa Agricultural Experiment Station directed toward a study of losses from wind and fire and means of preventing them. It has been continuously cosponsored by the Iowa Mutual Tornado Insurance Association and the Farmers Mutual Reinsurance Company. This paper reports a statistical study of the 20-year results from this project.

For both wind and fire studies statistical analyses of the actual loss experience were considered of primary importance. Statistical data were needed to establish the magnitude and distribution of the various types of damage in order that an intelligent follow-up program could be designed. Once having established the justification for certain phases of a continued program, structural analyses, laboratory tests, and building design may be undertaken.

An annual study of the loss experience of the Iowa Mutual Tornado Insurance Association was undertaken in 1930. Inasmuch as they now carry over 1¼ billion dollars of windstorm risks primarily on farm buildings throughout Iowa, their loss experiences are representative of the entire state.

Due to the very laborious task of recording the data from the thousands of claims paid annually by the Association, four years data (1930-33) only were taken initially. Analysis of some 30,103 losses for the period amounting to $1,044,886 has been sufficient to establish a bench mark for later comparisons. In 1946 the collection of annual data was again undertaken, and in 1948 the Association changed their administrative setup to include the use of Hollerith cards so that all tabulations may now be made readily on IBM machines. The loss data are placed immediately on cards as the claims are processed for payment, hence are readily available for tabulation and analysis. Without such a system the loss experience consisting of some 75,000 losses resulting primarily from the two recent devastating storms of October 10, 1949, and May 5, 1950, could not be tabulated readily.

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1950, as a contribution of the Farm Structures Division. Approved for publication as Journal Paper J-1922 (project 1167) of the Iowa Agricultural Experiment Station.

The authors: MERLE L. ESMAY and HENRY GIESE, respectively, assistant professor and professor of agricultural engineering, Iowa State College, Ames.

Due to the comparatively smaller numbers of fires, and the state law requiring that all fires be reported to the state fire marshal, a complete picture of the farm fire waste has been somewhat easier to obtain. Annual tabulations of the farm fire waste have been made continuously since 1930. An analysis of the fire waste situation completed a few years after 1930 provided the basis for a comprehensive fire-prevention program. Favorable results from the fire effort have stimulated the initiation of similar action directed toward windstorm damage.

Fig. 1 shows what has been accomplished through the fire program. Linear regression lines have been calculated in order to bring out straight-line trends for each set of data represented on the graph. The lower broken line indicates that farm fire damage on a dollar basis, in the face of the recent inflation years, has been reduced by 53 per cent from 1930 to 1948. On the other hand, city fire damage in Iowa has increased 81 per cent in the same period. The drastic increase of city fire damage occurred from 1942 on until 1948; however, farm fire damage increased but very little during that same period of inflation.

The shaded area of Fig. 1 shows a 60 per cent increase of wind damage to farm buildings in Iowa for the same 19-year period. As indicated by the annual wind loss values plotted separately on the graph, such damage is very erratic. The amount of damage for any one year depends on the severity of the windstorms; however, over a period of years such as represented it is believed that such a regression line as the one for these wind data does have some significance in indicating a trend. The increase in wind damage over the 1930 level does not include either of the two more recent devastating windstorms of 1949 and 1950.

As indicated by the wind regression line on Fig. 1, the rate of annual wind damage in 1948 was a million dollars per year. This is based on the assumption of 1¼ billion dollars risk in force and a loss ratio of 80 cents per thousand dollars. If a reduction in this rate of wind damage could be brought about to bring it back to the 1930 level, a saving of some 400 thousand dollars per year could be realized by the members of this one mutual.

Of primary importance in an analysis of wind damage is the distribution of the damage by type. Fig. 2 shows graphically the comparative amounts of damage by type for the three periods, 1930-33, 1946-48, and October 10, 1949. The eight principal types of damage only are presented on this graph. The solid bars represent amounts of damage in dollars and the crosshatched ones the number of losses, both represented as a per cent of the total rather than in actual values in order to place them all on a uniform basis. The October, 1949, windstorm was plotted separately in all cases to show any variances in type and magnitude of damage caused by a single storm of somewhat known velocity and magnitude.

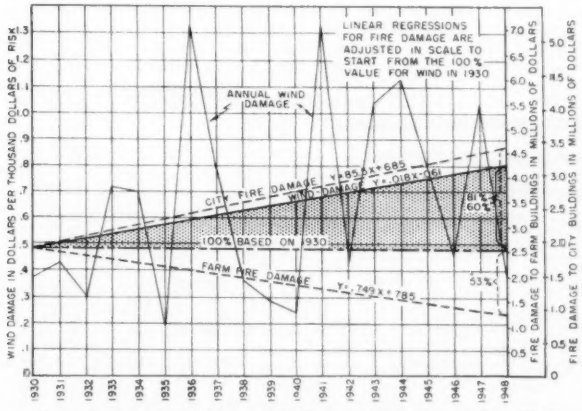

LINEAR REGRESSIONS FOR FIRE DAMAGE ARE ADJUSTED IN SCALE TO START FROM THE 100% VALUE FOR WIND IN 1930
ANNUAL WIND DAMAGE
CITY FIRE DAMAGE Y=.85X+.685
WIND DAMAGE Y=.01X+.761
81%
60%
100% BASED ON 1930
FARM FIRE DAMAGE Y=-.749X+.785
53%
WIND DAMAGE IN DOLLARS PER THOUSAND DOLLARS OF RISK
FIRE DAMAGE TO FARM BUILDINGS IN MILLIONS OF DOLLARS
FIRE DAMAGE TO CITY BUILDINGS IN MILLIONS OF DOLLARS
1930 1931 1932 1933 1934 1935 1936 1937 1938 1939 1940 1941 1942 1943 1944 1945 1946 1947 1948

Fig. 1 Trend of annual wind and fire damage to Iowa farm and city buildings

Demolition or total loss of buildings by wind has continued to be the dominant type of loss so far in dollar damage. The number of losses of this type is comparatively small due to a much higher magnitude of individual losses. The indicated decrease of approximately 25 per cent in demolition damage does not necessarily represent a decrease in dollar damage but rather a large increase in roofing damage and slight increases in damage to doors and some other types. The increase of roofing damage from 3.83 per cent in 1930-33 to 17.5 per cent for the October, 1949, storm indicates an increase of 4.57 times within a period of 20 years. The number of roofing losses has shown a similar increase. Fig. 2 indicates for the latter periods

that approximately one out of every three loss claims received by the association was for damage to roofing. The individual losses are quite small amounting to an average of $21.30 for October, 1949, but the total amount of damage to roofing paid out for the storm amounted to over $225,000. Roofing damage from the May, 1950, storm was much greater but not yet accurately established.

For simplification of analysis, the various types of damage have been grouped into two categories. Demolition, out of plumb, off foundation, roof off, end or side out, and miscellaneous structural damage are designated as major structural failures. The remaining types of damage, including damage to roofing, doors, windows, etc., make up the second group called minor type damages. These latter types of damage are not necessarily minor in total magnitude but are failures of a type which do not tend to cause the building to collapse.

Fig. 3 shows that major structural accounts for the greater portion of the dollar damage. Percentagewise, major structural damage has dropped some 20 per cent resulting from an increase in minor damage. The division of the bars representing minor damage indicates that portion charged against roofing for the various periods. It is very important to note that minor damage exclusive of damage to roofing has continued almost on a level of approximately 18 per cent throughout the 20-year period and that damage to roofing has been responsible for practically all of the increase of the minor type classification. The percentage of minor type losses excluding roofing shows some decrease indicating that the roofing losses more than account for the increase in number. Due to the nature of the minor type damages as classified and the indicated trivialness of them individually, it is believed that they are in general a preventable type damage which occur mainly because of the lack of maintenance and repair of the buildings and possibly the inherent weakness of certain materials.

The major structural type damage occurs mainly because of an inadequate basic design of the building and poor construction in general. Observation of many wind-damaged farm buildings has established the fact that nearly all structural failures are in the joints instead of the members. It is believed that substantial reduction in major structural damage can be attained through research on fastenings, improved design, and education of builders and farmers.

The existing farm dwellings appear to be almost immune from major structural failure. Fig. 4 shows that for the October 10, 1949, windstorm in Iowa only slightly over one per cent of all the major structural damage to farm buildings was sustained by the dwellings. In actual dollar damage recorded, this amounted to only $9,803 out of a total of $819,216 of major structural type damage to all farm buildings. Seldom is a dwelling demolished or even blown out of plumb by anything short of a tornado. Fortunately tornado damage in Iowa causes a comparatively small portion of the wind damage. The farm dwelling accounting for about one-half of the farm building investment in Iowa indicates that at least half of the farmer's building dollar is now being spent for structurally wind-resistant buildings. It is well within an economically sound program that the other half dollar could easily be made into wind-resistant construction with very little added to it other than knowledge.

Nearly half of all the structural damage, as shown by Fig. 4, has been sustained by the barn. By definition, for these tabulations, the barn has been generally taken to mean the two-story-type, general-purpose or dairy structure, with overhead hay-storage space. Due to the nature of

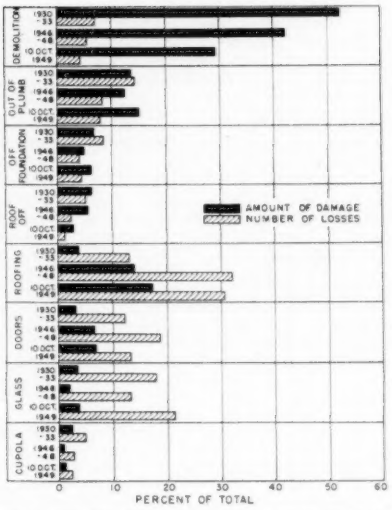


Fig. 2 Iowa farm building damage by all causes except hail

a second-story open mow with a width of usually 36 ft to accommodate two rows of stanchions below, the barn is very vulnerable to wind damage. Improvement of barn design and construction in accordance with good engineering principles promises substantial reduction in wind damage at little or no additional cost. This requires research on fastings and structural techniques and the education of farmers and builders.

Fig. 5 emphasizes the trivialness of many claims in showing that about 90 per cent of the losses are less than $70. The amount of damage represented by this same range of damages is somewhat less than 40 per cent of the total. The curves all originate at about five dollars because the Association has placed a minimum of this amount on accepted claims. Even though on these curves both major structural and minor damages have been plotted together most of the small losses are of the minor type. The average size of loss of the minor type during the October, 1949, windstorm was only $17.50, and in 1946-48 it was $23, as compared to $168 for the major structural losses in the latter period.

From the curves representing number of losses it is noted that 40 per cent of all the losses during the October, 1949, storm were for $10 or less as compared to about 35 per cent for the 1946-48 period. With over half the losses being considerably less than twenty dollars for all periods, it is evident that such losses are of a very minor nature individually

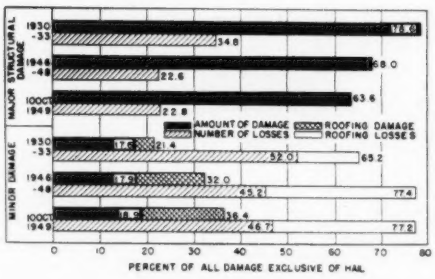
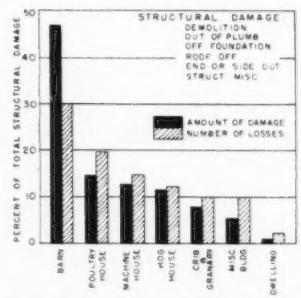


Fig. 3 *(Left)* Major structural and minor wind damage to Iowa farm buildings • Fig. 4 *(Right)* Structural damage of buildings in the October 10, 1949, windstorm



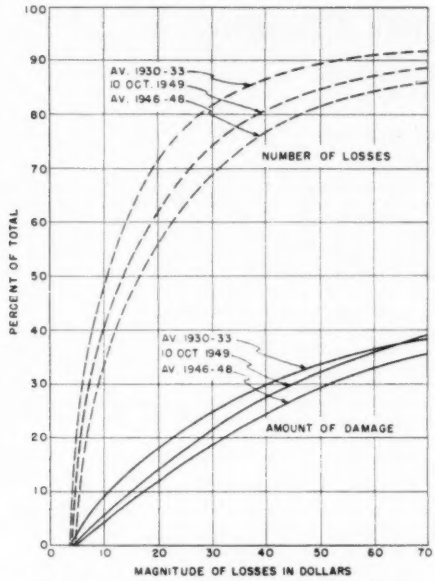


Fig. 5 Distribution of magnitude of farm building wind-damage losses

and could be eliminated with a continued program of preventive maintenance on the part of the farmers. The lower curves representing dollar damage do not rise as fast because the small losses add up much slower than the larger ones. It is of interest to note that the October, 1949, storm caused a greater proportion of small losses than the preceding three year period of 1946-48. The magnitude of loss is dependent to a great extent on the characteristics of the windstorm. The October, 1949, storm resulted in a high proportion of minor damages, windows, doors, roofing, etc., and some structural damage such as buildings blown out of plumb and off foundation; but it was not of the severe devastating type causing many buildings to be completely demolished.

The change in the distribution of magnitude of losses, comparing the 1930-33 period with the 1946-48 period, indicates a trend away from such a high percentage of small claims. The proportion would be much smaller than indicated for the latter period if damage to roofing with the average size losses of 20 to 25 dollars had not increased as it did since 1930-33.

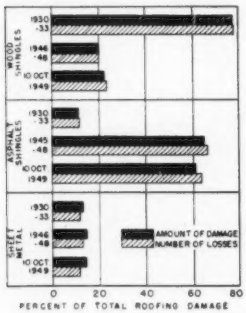


Fig. 6 Wind damage to Iowa farm building roofing

Due to the rapidly increasing problem of wind damage to roofing materials in the last twenty years, it has been felt necessary to analyze this phase of the loss experience in more detail. Fig. 6 shows the distribution of roofing damage by type of roofing material for the various periods studied. A reversal of trend is brought out on this graph. Damage to wood shingles has reduced from about 80 per cent of all damage to roofing in 1930-33 to 20 per cent in 1946-48 and slightly more than 20 per cent for October, 1949. In contrast to this percentagewise reduction of damage to wood shingles, damage to asphalt shingles has increased proportionately. The damage to asphalt shingles has increased from 11.1 per cent of the total roofing damage in 1930-33 to 64.5 per cent in 1946-48, or nearly six times within 20 years. The seriousness of this increase of asphalt-shingle damage is emphasized by the findings of a roofing survey by the Iowa Agricultural Experiment Station in 1948, which found that only one-eighth of the area of all farm building roofing in Iowa was asphalt shingles.

SUMMARY

Millions of dollars are wasted annually through unnecessary wind damage to farm buildings. In Iowa alone one insurance association paid out approximately 1½ million dollars for wind damage resulting from the October, 1949, storm and over twice that amount for a similar but more devastating storm in May, 1950. It may be argued that major structural damage such as demolition of buildings is inevitable, but the October, 1949, storm demolished buildings averaging only $263 in insured value while the average of all buildings insured was well over $1,000. Many such buildings demolished constituted the only damage of any sort sustained by the buildings of a farmstead indicating that only the lowest valued buildings, undoubtedly in a state of great disrepair, were affected by the winds. On the other hand, some apparently substantial barns were demolished due to lack of consideration to fastenings such as the adequate anchoring of roofs. Nearly all such damage could have been prevented with but little extra outlay of money.

The major problem then lies in the design and construction of farm buildings with better bracing, more secure anchorage, and with greater tensile-resistant and rigid fasteners in general. Minor type damages are preventable through continued maintenance and repair of the buildings, except possibly for the rapidly increasing problem of wind damage to roofing. This problem is separated from the other minor types because of its increasing magnitude and the fact it will require a cooperative effort on the part of roofing manufacturers and applicators to obtain wind-resisting roofing economically.

All-Out Production in Agriculture

THE basic contribution of the farmer to the defense program is adequate production. He must feed and clothe 150 million Americans, must produce materials for military supplies, and must furnish food to friendly nations standing beside us in the fight against communistic aggression. To help meet our economic needs, farmers must produce the quantities and kinds of products necessary to help stabilize prices and minimize the disruption to our civilian economy caused by the defense program.

To encourage more agricultural production, decisions were made after the Korean crisis to remove crop-allotment provisions from wheat and rice and to establish no allotments for corn and cotton.

These important moves preceded formulation of a comprehensive production guides program by the Department of Agriculture to assist farmers in planning all-out production in 1951. This program as it affected the major food, feed, and fiber crops was announced February 2, well in advance of planting time.

The program calls for a total agricultural production larger than ever before — 3 per cent higher than the previous record.

The production guides seek the highest level of production for those crops which will be needed most. The program calls for the highest practicable increases for corn and wheat, the major food and feed grains. About 60 per cent more cotton is sought than was produced in 1950 — 16,000,000 bales — or about the same amount as the high output of 1949. An increase of 22 per cent in production of vegetable crops for canning and freezing is asked, along with greater output of seeds for hay and forage crops essential to greater livestock production and for conservation of soil resources for insuring adequate production in the future.—*From first quarterly report to the President by Director of Defense Mobilization Charles E. Wilson.*

Radiant-Energy Chick Brooding

By K. C. Seeger and J. H. Oliver
MEMBER A.S.A.E.

REPEATED tests in the Midwest, in New York state and at the University of Delaware have proved that high air temperatures are not necessary for the successful brooding of chicks, provided they receive sufficient radiant energy to keep them warm. These conclusive tests were carried to the extreme of brooding baby chicks in an air temperature of 15 F below zero.

In this extreme test the Delaware Power and Light Co. and the University of Delaware cooperated in placing, on March 29, 1950, 30 chicks in the Isaacs Cold Storage Plant (Fig. 1) in Georgetown, Del., where air temperatures are maintained at 5 to 15 F below zero. At the end of two weeks the 30 chicks were larger, 1.9 lb per one hundred heavier, and better feathered than others of the same hatch, which were brooded in the conventional manner in a warm room under coal stove brooders.

Four 250-w infrared lamps, spaced 12 in apart each way, with the ends of the lamps 18 in above the litter, and operated at 125 v, supplied the radiant energy that kept them comfortable at all times. That they were comfortable was shown by their actions in eating and sleeping and the absence of the type of chirping characteristic of chilled chicks. Vent pasting, commonly associated with chilling, occurred in only one chick.

Radiant energy at chick level measured 2.62 Btu per sq in. This heated the chicks but contributed little heat to the jars of water, so that half of the water in the jars was frozen continuously and one jar was broken by the water freezing. At the end of the second week the chicks were wing banded and returned to the University test station where they were placed with 450 others being raised under infrared lamps. No adverse aftereffects were noted, and although these 30 missed being vaccinated for Newcastle, 29 survived to be sold at 12 weeks of age.

We are often slow in recognizing facts that nature has been demonstrating for centuries. In our boyhood days many of us have witnessed a hen with a batch of chicks running around in the sunshine on a cold day early in spring. As long as there was no wind blowing, the chicks were comfortable for long periods without seeking shelter under the hen. Also, it is not unusual to see chicks in a cold brooder house leave the brooder to lie in the sunshine — perfectly comfortable as long as the sun was shining on them.

The sun cannot be kept shining through the window at all times, but the energy level can be duplicated so that the chicks are just as well satisfied. What are the energy requirements for brooding chicks at various air temperatures? Knowing that, how can we simplify brooding methods to take advantage of this information to reduce labor, capital investment and brooding cost per chick?

Information as to the energy requirements of chicks was published in 1933,* which presented data (Fig. 3, curve 3) on chicks weighing ½ to 7 lb. This showed the estimated heat required to maintain chick body temperature, in excess of that furnished by the basal metabolism, for each degree that the environmental air temperature fell below 62 F.

It has been assumed that day-old chicks required about the same amount of energy for each degree below normal brooding temperature as the ½ lb chick does for temperatures below 62 F, hence the curve has been extended (dotted portion) to include chicks from 1 day to 3 weeks old. For comfort this energy level must be available to the chick at all times. In practice it represents an adequate area under an infrared heat lamp where the chicks gather when cold or at rest and where they may receive the required Btu per square inch of energy.

Fig. 3 presents data on the average minimum weight for broilers (curve 2), the body area of the chick which can absorb radiant energy (curve 1), and typical minimum brooding temperatures (curve 4). With this information, calculations were made of energy levels required for chicks from one day to seven weeks old when brooded in air temperature from 0 to 80 F. Typical calculations are plotted in Fig. 4.

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1950, as a contribution of the Rural Electric Division.

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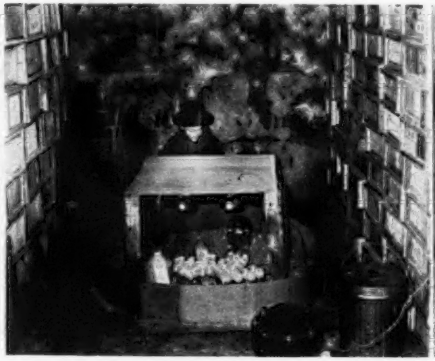
AUTHORS' NOTE: The authors wish to express their appreciation for the cooperation, photographs and test data received from W. C. Pierce, industrial manager, Southern Div., Delaware Power and Light Co.; Bentley Wilson, superintendent, *Poultry Tribune*, and J. P. Ditchman and R. J. Gorzegno, General Electric Co.

*Mitchell, H. H. and Kelley, M. A. R.: Estimated Data on the Energy, Gaseous and Water Metabolism of Poultry for Use in Planning the Ventilation of Poultry Houses. Journal of Agricultural Research, USDA, vol. 47, no. 10 (Nov. 15, 1933).



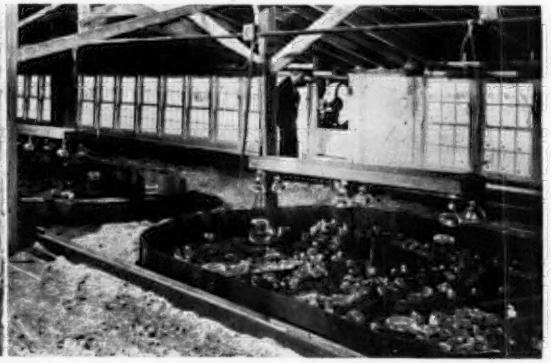


Fig. 1 *(Left)* Test-raising chicks under infrared lamps in a freezer locker at 15 F below zero at Georgetown, Del. • Fig. 2 *(Right)* Radiant-energy brooding showing position and mounting of the infrared lamps with chicks confined to the vicinity of the heated area during the first week. Ventilating fan, automatic feeder and pipe for automatic feeder, and pipe for automatic waterer are also shown

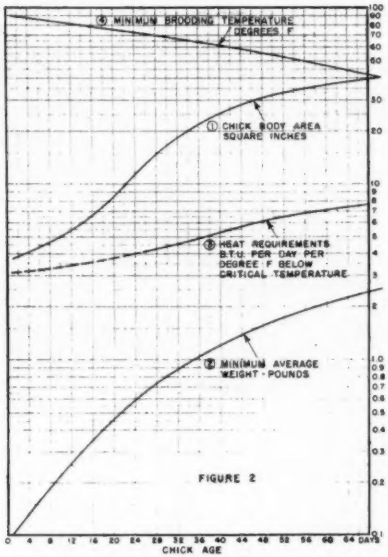

④ MINIMUM BROODING TEMPERATURE / DEGREES F
① CHICK BODY AREA SQUARE INCHES
③ HEAT REQUIREMENTS B.T.U. PER DAY PER DEGREE F BELOW CRITICAL TEMPERATURE
② MINIMUM AVERAGE WEIGHT - POUNDS
FIGURE 2
CHICK AGE

Fig. 3 These curves show (1) chick body area vs. chick age, (2) average weight vs. chick age, (3) heat requirements Btu per day per deg F below critical temperature vs. chick age, and (4) minimum brooding temperature vs. chick age

The calculated energy levels of Fig. 4 agree well with test results, especially since the various tests used different breeds of chicks. Only a few of the test points at various temperatures are shown on Fig. 4 to avoid confusion. It is recognized that rapidity of growth and feathering will influence the chicks' energy requirements; the slower feathering breeds will require more energy than the fast-feathering New Hampshire and associated breeds. Checking the chicks' requirements the first day was relatively easy, as day-old chicks are quite outspoken when uncomfortable. The energy level was raised till their loud chirping stopped and they ceased huddling.

The other end of the curves are not so definite but, in general, agree with good brooding practice; in fact, experienced poultrymen can quickly check several points on these curves which agree with established brooding procedure. For example:

1 With heated-floor type of brooding, using heating cable or hot water pipes buried in the brooder house floor, an air temperature in the room of 82 to 85 F is required. The Btu per square inch from the heated floor is about 0.5, which checks the 80 F curve.

2 Winter sunshine at Georgetown, Del., measured 2.1 Btu per sq in, which corresponds with the 30 F curve. We know that chicks are comfortable in a 30 F house as long as midday sun is shining directly on them through a clean glass window and there are no floor drafts.

3 Heat is usually turned off between the second and third week with midsummer brooding, which checks the zero end of the 80 F curve.

4 Similarly heat is turned off by the sixth week for spring brooding when night temperatures are 60 F. In winter with lower brooder-house temperatures heat may be continued till the eighth week if necessary.

The advantages of using radiant energy with or without supplemental heat are as follows:

1 It is applicable to all sizes of brooder houses — 100 to 40,000 chicks or more.

2 The chicks are visible at all times, making it easy for the poultryman to observe any abnormalities or signs of disease in the flock.

3 The chicks can select the energy level best suited to their desires. (Chicks which have become chilled and the weaker ones pick a warmer spot than the stronger ones.) Thus there is no chance of overheating. During the first few weeks when the lamps are only about 1½ ft above the litter, the energy level directly under the lamp is about 50 per cent greater than the average needed by the chicks. This provides quick warm-up for the cold chick.

4 Cool-room brooding produces fast-feathering chicks with keen appetites for rapid and healthy growth.

5 Labor is reduced, as it is easy to feed and water the chicks from the first day since there is no brooder to interfere and thermostats automatically take care of providing correct energy for the chicks.

6 Cleaning of the house is as easy as with heating cable or water pipes buried in the floor. There are no brooders to move, clean or store. The lamps or lamp units are raised out of the way at the end of the brooding period, but are still available at the snap of a switch to supply heat to the chicks in case of a cold night.

7 Maintenance and replacement of parts is practically negligible.

Following are methods of applying this new idea of radiant energy brooding:

1 It can be used to supplement a heated floor, thus allowing the floor and air temperature in the brooder room to be operated below 85 and 90 F. This eliminates the possibility of overheating on a warm day.

2 Instead of heating the entire floor of the brooder house, only a small area, about 12 sq in per chick, need be heated to 85 F when supplemented by radiant energy on the chick's back. Thus desirable coolroom brooding results since the air in the house is not heated more than when an electric brooder is used.

3 Radiant energy can be used alone. In large installations brooding 10,000 to 40,000 chicks this is the most economical method when used with an automatic regulator control.

HEATED FLOOR PLUS RADIANT ENERGY

The most practical and safe unit readily available today for producing radiant energy is the infrared-heat lamp available in 125, 250 and 375-w sizes.

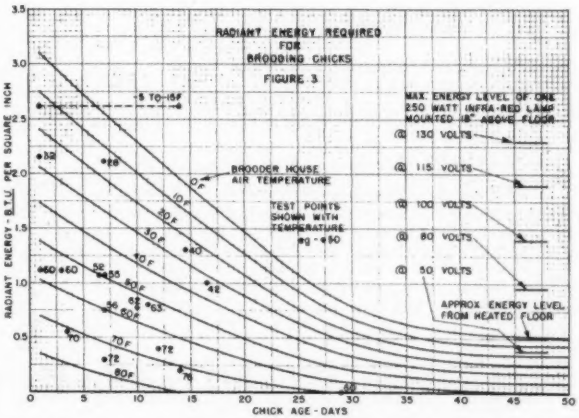

RADIANT ENERGY REQUIRED FOR BROODING CHICKS
FIGURE 3
MAX. ENERGY LEVEL OF ONE 250 WATT INFRA-RED LAMP MOUNTED 18" ABOVE FLOOR
130 VOLTS
115 VOLTS
100 VOLTS
80 VOLTS
50 VOLTS
BROODER HOUSE AIR TEMPERATURE
TEST POINTS SHOWN WITH TEMPERATURE @ - 60
APPROX ENERGY LEVEL FROM HEATED FLOOR
RADIANT ENERGY - B.T.U. PER SQUARE INCH
CHICK AGE - DAYS

Fig. 4 Radiant-energy requirements of chicks from 1 day to 7 weeks old with brooder room temperature from 0 to 80 F

Infrared lamps have been used very successfully in several experimental installations in combination with heating cable buried in the top half inch of the cement floor. The heating cable was installed on 6 and 8-in centers with insulation or an insulating-type cement beneath the cable. This produced floor temperatures of 85 to 90 F with room temperatures from 50 to 70 F, depending on how well the house was insulated.

Two rows of infrared lamps, mounted 2 ft above the litter and spaced 2½ ft apart, were located in the center of the room. One lamp is used for each 100 chicks. Floor temperature was thermostatically controlled. The lamps controlled by hand switch are turned off permanently when the chicks are 10 days to 3 weeks old, depending on ambient temperature. The average energy per chick for midwinter brooding varied from 2½ to 4 kw-hr depending chiefly on how well the house was insulated.

By referring to Fig. 4, it is easy to see that potential savings in kilowatt-hours can be made by operating the lamps on thermostat also. They should be turned off on the 10th day whenever the room temperature reaches 70 F; on the 15th day when it reaches 60 F, etc. The heat from the floor is adequate to take care of the chicks' needs under these conditions.

No litter was used other than ¼ in of sand; the floor remained dry at all times.

Mortality was usually less than 2 per cent. Thermostatically controlled electric fan ventilation was used to remove moist air from the house after the 2nd or 3rd week.

This type of brooding has been installed in a variety of houses from the small 10 x 12 ft brooder house up to two-story houses of 4,000 sq ft floor space.

Air temperatures with this type of brooding in insulated houses are usually between 50 and 70 F during the winter months.

Turkeys have also been successfully raised with this type of brooding.

HEATED SPOT PLUS RADIANT ENERGY

Instead of heating the entire floor several successful test runs were made in the Midwest and in New York state during the past season. Only a small area of the floor (about 12 sq in per chick) was heated with heating cable. This was thermostatically controlled to maintain a maximum of 90 F on the surface of the heated area the first day, and was reduced 5 degrees per week. Infrared lamps which were spaced 2 ft apart were mounted 18 in above the heated area, one lamp for each 70 chicks for brooder house temperatures down to freezing temperatures. These lamps were also thermostatically controlled to be turned off when air temperatures in the house rose to preset levels of 80 and 70 deg, etc., previously mentioned. In addition, the lamps were raised 1 in per week to increase the area of radiant energy required by the growing chicks.

The heated area was covered with ¼ in of sand; the rest of the brooder house floor had 2 in of litter. Two-by-four's outlined the heated area and prevented the chicks from scratching insulating litter onto the heated area during the first few days.

Feed and water were placed on the heated area at first and gradually moved out as the chicks grew. No frozen water fountains resulted although air temperature in the brooder house was frequently below freezing during the first two weeks.

As in conventional brooding, cardboard barriers must be used during the first week or two to prevent floor drafts and to confine the chicks to the vicinity of the heated area.

No floor drafts, easy access to feed and water, and a free choice of desired heat level appear to be the main factors which contributed to the low mortality of ½ per cent in the New York spring brooding test.

Dry litter was easily maintained with fan ventilation started the third week.

Total energy per chick for brooding, ventilation and night lights was 2¼ kw-hr per chick for spring brooding in a tight but uninsulated brooder house.

It is believed that winter brooding in a well-insulated house would not average over 2½ to 3 kw-hr.

RADIANT-ENERGY BROODING

In most of the large broiler-raising areas the houses are single story without floors. Here radiant energy alone has proved most economical to install and operate. Broiler units are usually 20,000 chick size, with some new houses being built at the present time for 40,000 chicks.

This size installation is large enough to warrant the cost of a control unit which will control the voltage of the lamps to produce the desired level of energy on the chicks at all times. An induction voltage regulator controlled by the air temperature in the house maintains voltage on the lamps at the correct level as the temperature in the house varies from day to night or on cold days. It lowers the voltage, to save kilowatt-hours as the temperature in the house rises. This regulator holds a voltage of 44 to 136 v on the lamps as required by the temperature control; also, it compensates for variations in line potential. The top limit, 136 v, is lowered each week as the chicks grow and need less energy as shown in Fig. 4.

Six 250-w infrared industrial R-40 type heat lamps with selfcontained reflectors are mounted in pairs at 40 deg to each other, and spaced 2½ ft between pairs (Fig. 4). They are placed 18 to 20 in above the litter the first day, and raised 1 in each week to give adequate coverage without crowding the 500 growing chicks. Chicks are confined to the vicinity of the radiant energy area for the first week to ten days after which the barrier is removed and the chicks have the run of the house.

Three lots of 900 chicks have been successfully brooded at the University of Delaware test station at Georgetown. The first was started November 9, 1949. Average weight, feed efficiency, and mortality have been normal. There is a considerable saving in labor, however, as compared with operating the coal stoves in the balance of the test station.

Two lots of 20,000 each have been brooded at the Townsend house at Millsboro, Del., and the third lot is now 8 weeks old. Total electric energy for the first lot (started March 21, 1950) was 1.57 kw-hr per chick for brooding and a grand total of 1.68 kw-hr per chick for all purposes, including the operation of the water pump, two automatic feeders, six ventilating fans and the house lights.

The second lot (started June 6) used 0.297 kw-hr per chick for brooding and a grand total for all purposes of 0.53 kw-hr per chick. It is believed that in Delaware normal electrical usage will be 2 to 2½ kw-hr per chick for winter brooding, 1¼ to 1½ kw-hr for spring and fall, and ½ kw-hr for summer brooding for all purposes, including brooding, feeding, watering and house lights. This is based on an estimated minimum air temperature in the house of 40 F for winter brooding.

It should be noted that raising chicks under infrared lamps is not at all new, as literally millions of chicks are being raised each year under homemade brooders using infrared lamps as a source of heat.

CONCLUSION

Tests have shown that, when arranged in groups of two or more, one 250-w infrared lamp will be adequate for brooding 80 chicks where brooder room temperature does not go below 50 F. This number may be increased by one chick for each degree the minimum temperature is above 50 F, and should be decreased one chick for each degree the brooder room temperature is below 50 F. Five to ten more chicks may be added per lamp when voltage regulators are used to provide 130 v or more.

Where automatic waterers, feeders and fan ventilation are provided, radiant-energy brooding makes it possible for one man to take care of at least 60,000 chicks when they are started at the rate of 20,000 chicks every four weeks.

Thus a new combination of standard devices provides the poultryman with new brooding equipment to enable him to raise more chickens with less labor and at a lower cost.

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RESEARCH NOTES

A.S.A.E. members and friends are invited to supply, for publication under this heading, brief news notes and reports on research activities of special agricultural engineering interest, whether of federal or state agencies or of manufacturing and service organizations. This may include announcements of new projects, concise progress reports giving new and timely data, etc. Address: Editor, AGRICULTURAL ENGINEERING, St. Joseph, Mich.

USDA Agricultural Engineering Research

Secretary of Agriculture Charles F. Brannan urges American farmers, with the aid of industry, to keep their farms in good shape mechanically to meet the nation's defense food needs by conserving farm machinery and equipment and repair parts. He says, "One of the first and most vital requirements of farmers today is for an adequate supply of production tools. The need for maintaining an adequate supply of farm machinery and equipment is on us now, since food demand for the 1951 crop year is heavy. And we must look to the future, when food needs may be even higher. An essential aid in keeping our farms in good condition mechanically is for farmers to take all steps possible toward keeping their machinery and equipment in a constant state of repair and to use it under conditions that will cause the least wear."

He urges farmers to survey their individual needs now and place their orders, particularly for repair parts. Industry, it is hoped, will increase the output of repair parts and other items needed by farmers in the efficient maintenance of farm machinery.

Farm production has increased 20 per cent since 1941, with the aid of mechanization, while the labor force has dwindled since 1941 by about one million workers. This means that farm workers must be skilled to use the mechanical equipment on farms, and that the equipment is essential in sustaining full production of food and fiber. Machine operations on the farm are illustrated by the following examples: From 1941 to 1950, tractors increased from 1.7 to 3.8 million, trucks from 1.1 to 2.2 million, milking machines from 210,000 to 710,000, combines from 225,000 to 650,000, and mechanical corn pickers from 120,000 to 410,000.

While it is fortunate American farmers are better equipped than ever before with farm machinery and other mechanical facilities, this also makes farmers more dependent on the products of industry. For most farms, it is now a case of machinery or greatly reduced output.

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Fertilizer Placement Boosts Onion Yields. The importance of correct fertilizer placement in relation to crop seeds and plants in muck soil was high-lighted in recently reported research by scientists of Michigan State College and the U.S. Department of Agriculture. Their detailed study required, first of all, the development of a practical fertilizer-placement machine, and then repeated trials with various rates of fertilizer applied in different positions in respect to the seed.

The machine these scientists developed to do the job for them accurately seeds and fertilizes in one operation. The machine lays a one-inch band of fertilizer in vertical inch graduations directly below, to the side, or below and to the side of the seed. A correct combination of machine sprockets enables the research workers to apply from 100 to 2,000 lb of fertilizer per acre. The machine will seed and fertilize four rows 14 in apart, 2 rows 28 in apart, or any other combinations within these limits.

On Michigan-grown commercial onions, localized fertilizer placement increased yields in 1949 and 1950 an average of 55 per cent over onions fertilized by grain-drill broadcasting equipment. Furthermore, the scientists found that 400 lb of fertilizer correctly placed in relation to onion seed produced as many bags of onions per acre as 800 lb of fertilizer put on with a grain drill.

More limited fertilizer placement studies have shown comparable results on such muck soil commercial crops as celery, cauliflower, cabbage, table and sugar beets, carrots, potatoes, and parsnips.

Agricultural engineers believe that these results indicate that a machine that can accurately place given amounts of fertilizer has a place on many of this nation's farms. The fact that fertilizer placed below but to one side of the seed is as effective as that placed directly below the seed, will be important to consider in the design of such a machine, they say. A seeder-fertilizer that will place a band of fertilizer alongside and below the seed will find wider usage among farmers raising other crops on muck soils and will be more foolproof than a machine designed to place fertilizer directly below the seed.

• • •

Canvas Tunnel Solves Cold-Weather Potato-Loading Problem. In below zero weather it has been almost impossible to move Red River Valley potatoes from warehouse to railroad cars because of freezing damage. Now research engineers of the U.S. Department of Agriculture, working at East Grand Forks, Minn., have developed a canvas tunnel that fits between warehouse door and railroad car door, so that the potatoes can be moved during below zero cold. Temperatures in both the cars and the warehouse are kept above freezing.

Previously it was often impossible to load potatoes on more than half of the days during the winter months. Growers were unable to fill orders and lost sales. Shippers were forced to stop grading and to lay off working crews. Railroads had sidings full of unwanted cars during below zero weather, and were often unable to handle the accumulated business when the weather moderated.

The tunnel is a weather-resistant connection between warehouse door and refrigerator car door. It is permanently attached to the warehouse and can be quickly fitted into the car doorway by means of an adjustable frame. The tunnel can be designed to fit any size doorway, although a 27-ft circumference will let it fit any standard doorway, varying from 48 to 79 in in width and 78 to 96 in in height.

• • •

Pea and Bean Huller Subject of USDA Circular Community-canning and frozen-food locker plants are expected to boost the quantities of vegetables they will handle in years ahead through use of an improved pea and bean huller developed by agricultural engineers of the U.S. Department of Agriculture and the University of Georgia. This time-and-labor saving machine is described in USDA Circular 856, Pea and Bean Huller for Use in Locker and Community Canning Plants.

Research on a better pea and bean huller got under way after a survey of 21 Georgia locker plants showed fruits and vegetables made up only 15.2 per cent of the produce the plants handled, mainly because of a lack of labor-saving equipment for hulling hand-picked pods of lima beans and field peas. By testing and modifying the most adaptable of hullers on the market, the engineers were not only able to turn out a machine that satisfied plant operators and patrons, but they also recommended changes to the manufacturer of the original huller, which he incorporated into a new machine that is now on the market.

Four community-canning plant operators, using the improved huller, received returns of from 7.6 to 33.3 per cent on their investment in the machine the first year, despite the fact that a poor vegetable crop, selling at a high price, discouraged much home processing. Locker plant patrons were pleased with the huller, as the machine did in minutes a job that formerly took hours of hand work. It requires from 3 to 10 min to hull a bushel of pea pods, and 5 to 10 min to hull a bushel of bean pods with the improved machine.

A copy of Circular 856, giving a complete report of the research methods and results, is available from the Office of Information, U.S. Department of Agriculture, Washington 25, D.C.

• • •

Frequent On-Farm Calibration of Spray Machinery Needed. Frequent checking or calibration of spray equipment by the operator on the farm offers the only accurate and practical way of applying correct amounts of herbicides to weeds, according to research by engineers of the U.S. Department of Agriculture. The investigations have shown that wear on the many parts of the sprayer, the speed at which spraying is done, and the care taken in mixing the herbicides with water, all cause variations in spraying rates that can seriously affect spraying results.

Two ways of calibration suggested by the engineers are: (a) Select the gallonage of mixed spray that is required per acre, and then by trial-and-error adjust the tractor speed and pump pressure to get this dispersal; and (b) select a convenient tractor speed and pump pressure and then see how much spray is applied per acre. With this knowledge, mix chemicals and water to get the strength spray required.

Even though the sprayer is calibrated, the causes of variation are still present. To do a good, safe job of spraying, it is necessary to continually check the operation and rate of application of the sprayer.

• • •

More Efficient Tobacco-Curing Barns. Tightening the construction of tobacco barns not only helps southern farmers do a better job of curing bright-leaf tobacco, but also offers them important savings in fuel and materials during this critical time, recent research indicates. Agricultural engineers of the USDA Farm Electrification Division suggest several research-founded recommendations for more efficient bright-leaf tobacco curing.

A curing barn with walls made up of tight sheathing and siding with a layer of builder's felt in between is their recommendation for sound, thrifty barn-wall construction. Many existing curing barns can be brought up to this standard by adding the builder's felt and another layer of siding. Insulating the barns provides additional tightness and saving.

A metal roof supported by purlins on rafters, rather than by close sheathing on rafters, allows heat to escape, while moisture in the warm air condenses inside the barn to make tobacco curing more difficult. Such construction can be improved by removing the roof and replacing the purlins with close sheathing and builder's felt. Some improvement can be made without removing the roof by fitting insulation board between the rafters and against the underside of the purlins. Insulation installed next to the roof offers no further advantage.

Correct ventilation is just as important as tightness the engineers say. If the barn is yet to be built, they recommend the use of a row of 4-in concrete blocks laid on their side in the foundation wall around the entire base of the barn. Wads of loosely *(Continued on page 284)*

Costly HIGH PRESSURE SPRAYING CAN NOW BE ELIMINATED

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RESEARCH NOTES

(Continued from page 282)

packed porous material can be shoved into the concrete block openings to achieve the desired bottom ventilation.

The research men suggest the use of an adjustable ridge-type ventilator for top ventilation. There should be a maximum of 12-sq-ft ventilator opening for a 16 x 16-ft barn.

An easy way that the engineers have found to judge correct top ventilation adjustment is to compare the readings of dry- and wet-bulb thermometers placed among the tobacco leaves. When the temperature difference becomes as great as 25 F, the farmer can begin closing the top ventilator. If the difference again reverts to less than 25 F, the top ventilator should be opened.

As maintenance of equipment results in longer life, the USDA engineers advise cleaning all curing equipment after the season has ended.

• • •

Mechanization Aids Cotton Production. Progress in cotton mechanization in the Southwest will aid production of 16 million bales needed this year, reports the U.S. Department of Agriculture, on the basis of work by the Department and 12 southern states agricultural experiment stations cooperating in the regional cotton mechanization project under the Research and Marketing Act of 1946. If enough materials and equipment are available and the weather cooperates, machines generally can substitute for the rapidly diminishing labor supply.

Agricultural Engineer R. F. Colwick, whose job it is to correlate the cotton mechanization research, emphasized that each bit of mechanization progress is being fitted into the whole cotton production picture in this cooperative study.

Work with deep-tillage equipment (moldboard plows and chisels) on some Alabama soils has resulted in improved weed and grass control, larger cotton yields and deep-rooted cotton plants that better resist the pull of mechanical cotton strippers, the engineer reports. Mississippi planting studies have shown that mechanized operations are made easier and require less seed and hoeing if the cotton seeds are hill dropped in leveled seedbeds. The machine developd to do this job quickly consists of a shallow-operating sweep cultivator mounted in front of a tractor to clean out the weeds, and larger runner wings on the rear-mounted planter to level the seedbeds after planting.

Recent research has shown that chemical weed control is likely to replace some early cultivation previously required in cotton production. Pre-emergence spray tests in Georgia reduced hoeing as much as 40 per cent. Pre-emergence spraying controls weeds during the critical 4 to 6 weeks after planting. Because of cost, post-emergence weed spraying has not yet proved an able competitor for mechanical cultivation. However, the cost of hand hoeing has been cut by as much as 55 per cent by post-emergence treatments. Widely used rotary weeders and sweep cultivators have been improved by Mississippi research so that they can be used behind high-speed, rubber-tired tractors. They give longer wear and better performance at no increase in cost.

Cotton fertilizer needs are being determined in North Carolina with a machine developed by the engineers of USDA and North Carolina that accurately places given amounts of radioactive granular fertilizers, which then can be scientifically traced as they are used by the plants. Further research is going forward on the expanding use of anhydrous ammonia in Mississippi. A modified grain drill has been successfully used in Georgia to seed cover crops in unharvested cotton.

Preliminary trials with an experimental brush-type cotton stripper, developed in Oklahoma, are showing promise of providing low-cost cotton harvesting, and tests of small, low-cost spindle-type harvesters in South Carolina this past season were encouraging, Colwick reports.

Crop-residue disposal, important because it lessens implement clogging and destroys insects, is being studied by both government and industry. They have cooperatively developed several promising machines from which will eventually come a moderately priced, commercial implement capable of destroying green cotton stalks as well as dry cornstalks and small brush.

• • •

Precooling Research Improves Fruit Handling. Fruit precooling research conducted by the U.S. Department of Agriculture engineers working at Wenatchee, Wash., may lead to improved handling and storage for this important industry of the Pacific Northwest.

The engineers have found that they can cool fruit in a high-velocity, cold-air tunnel many times more rapidly than it is normally cooled if placed directly into cold storage. Rapid cooling is important because it considerably lengthens the time that fruit can be held safely in cold storage, and it helps to prevent the growth of rot-producing diseases. Some California grape growers are already making use of previous USDA high-velocity, air-cooling research conducted for precooling grapes prior to shipment to market.

The engineers' experimental precooling tunnel was arranged so that the air could be directed from the cold storage room through the tunnel at high velocities before returning to the air-cooling unit. In one of the investigations, G. F. Sainsbury, engineer in charge of the tests, filled the tunnel with boxes of fruit on pallets and passed the cold air over the fruit at velocities ranging from 300 to 800 fpm. Cooling was accomplished 1½ to 6 times faster than in normal cold storage cooling. In another precooling arrangement, cold air was directed down into unlidded boxes of fruit at velocities as high as 2,700 fpm, resulting in cooling 9 to 40 times faster than cold storage cooling. In either arrangement the greater the air velocity, the faster the cooling.

Both methods hold promise of commercial application. Each results in more uniform cooling than room cooling, and each offers more efficient use of the cold air, as all of the air is circulated to pass over the warm fruit.

• • •

Lint Cotton Cleaner. The lint cotton cleaner, a recent research development of the U.S. Department of Agriculture, says Chas. A. Bennett, USDA engineer, is a piece of equipment that will help cotton gin operators meet the nation's need for 16 million bales of good quality cotton in 1951. It not only offers gin operators a way to fill the need for quality cotton, but provides them with a potentially wider market for their product. The cleaner is designed so that it can be by-passed in the cotton-processing line for buyers interested in quantity rather than quality.

The lint cleaner is located between the cotton gin saws, which remove the seeds from the cotton, and the compressor, which packs the cotton lint, preparatory to forming bales. Much of the large trash is removed from the cotton by cleaners and separators before it reaches the gin saws, while the lint cleaner removes the fine trash. Actually, the lint cleaner removes only about one-seventh of all the trash cleaned in the ginning process, but it is a significant amount, because it represents the fine trash that previously could not be removed. Lint cleaning generally improves cotton one-third grade.

• • •

Heat Pumps Studied. Electrical heat pumps in five Kansas farm homes have compared favorably with conventional air-conditioning systems, in installation and operation costs, according to studies by engineers of the U.S. Department of Agriculture and Kansas Agricultural Experiment Station during the last two years. The heat pumps also appear safer and offer a chance for petroleum fuel conservation.

Basically a refrigeration unit, the heat pump acts as such in the summer, transferring heat of the home to water, soil, or air, which carries the heat away. In the winter, valves are adjusted to reverse the heat pump's cycle so that it collects heat from the water or soil, and uses it to warm the house.

The Kansas homes equipped with heat pumps all made use of well water for both heating and cooling. Heat pump studies using soil instead of water as the air conditioner, are also under way. The heat pump operates about the same, with either soil or water.

Heat pumps rated at 3 and 5 hp are higher in cost than conventional home-heating systems, but their cost compares favorably with the combined cost of many separate home-heating and cooling systems. Accurate cost figures showed the heat pump that relied on well water operated as cheaply as oil or LP gas-burning furnaces. Figuring the cost of electricity at 1½ cents per kw-hr and fuel oil and LP gas at 15 cents per gal, the heat pump furnished, on the average, a 1,000,000 Btu of heat for $1.31. Fuel oil cost $1.53 and LP gas $1.88 for the same amount of heat. With more efficient air-duct systems, the heat pump might provide as much as 50 per cent more usable heat with the same amount of electricity.

Where water is used as the means of heat transfer, it must be available in ample quantities and at low cost for successful heat-pump operation, say the engineers. Heat-pump air conditioners have been installed in city homes, but generally, because of cost, city water is used over and over by circulating it in pipes under the soil adjoining the house to bring the water back to earth temperature. Disposal of water on farms need not be a problem. If it cannot be put to use, it can be run into a reservoir, from which it can seep slowly back into the well as it regains its earth temperature.

• • •

Expansive Houses. USDA Leaflet 301, "Expansible Houses," describes two expansible houses for which working drawings will be available. One plan starts out as a two-room and bath unit and may be expanded to include 3 bedrooms. The basic unit of the second plan contains a kitchen, living room, one bedroom and bath. It may be enlarged in two steps. The first addition includes a work room and a second bedroom. The second addition provides two more bedrooms. The working drawings for these plans are almost entirely pictorial in that they are developed in isometric for easy reading by farmers and others unused to reading conventional drawings. Copies of this leaflet are available from the extension service of the land-grant college in each state.

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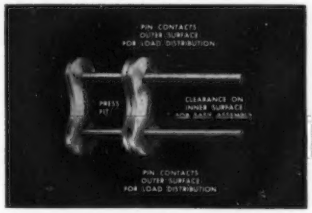

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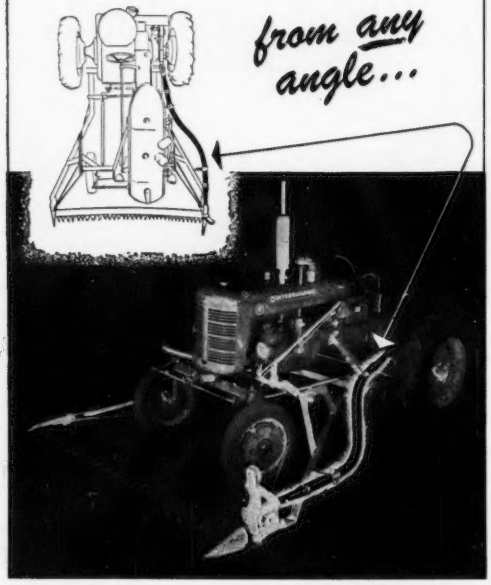
STOW CASE HISTORY No. 2



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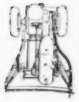

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NEWS SECTION

A.S.A.E. Meetings Calendar

June 18-20 — ANNUAL MEETING, Rice Hotel, Houston, Tex.

August 27-29—NORTH ATLANTIC SECTION, Chalfonte-Haddon Hall, Atlantic City, N. J.

December 17-19—WINTER MEETING, The Stevens, Chicago, Ill.

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to A.S.A.E., St. Joseph, Michigan

Agricultural Engineering in A.S.E.E. Program

A SPECIAL agricultural engineering program has been scheduled as one feature of the annual meeting of the American Society for Engineering Education at East Lansing, Michigan, June 25-29.

Fred A. Wirt (past-president ASAE), advertising manager, J. I. Case Co., will be the opening speaker. His luncheon address, Thursday noon, June 28, will be on the subject "The Role of Power Farming in National Defense."

Following the luncheon, an afternoon conference will open with discussion of "Objectives of Agricultural Engineering Curriculums." E. L. Anthony, dean of agriculture, Michigan State College, and R. M. Green, dean of engineering, University of Nebraska, are the scheduled contributors to this discussion.

"General vs. Special Operations in Agricultural Engineering Curriculums" will be considered next. L. W. Hurlbut, head, agricultural engineering department, University of Nebraska, will present the case for general options, and E. W. Lehmann, head, agricultural engineering department, University of Illinois, will discuss special options.

A paper, entitled "Analysis of Positions Held by Graduates in Agricultural Engineering," by Dr. R. K. Frevert, professor of agricultural engineering, Iowa State College, will round out the conference program.

The program has been arranged by a special committee (all ASAE members) consisting of H. J. Barre (chairman), R. H. Driftmier, E. W. Lehmann, H. B. Walker, J. D. Long, L. J. Fletcher, E. W. Schroeder, A. W. Farrall, and L. W. Hurlbut.

Power Line Safety Shields Available

TO MEET the needs primarily of small companies desiring to purchase safety shields for providing protection over the revolving power line between a tractor and power-take-off-driven machine, the major farm implement manufacturers are making available information on how these safety shields, of both the new non-removable type and the old telescoping type, may be obtained, without the smaller manufacturers having to go to the expense of providing tooling equipment to make the shields.

Several of the larger companies have made up special drawings of both the non-removable and telescoping-type shields. These drawings have been prepared so that from them any prospective purchaser may obtain complete information on the various sizes, lengths, etc., of the shields the various companies are in position to supply, and may then arrange for purchase from the company whose shield best meets his requirements.

Drawings or other information on both types of safety shields may be obtained direct from the engineering departments of most of the major farm implement companies. A small quantity of drawings supplied by four of these companies — Allis-Chalmers, J. I. Case, John Deere, and International Harvester — can also be obtained on request, as long as they last, from the headquarters office of the American Society of Agricultural Engineers at St. Joseph, Michigan.

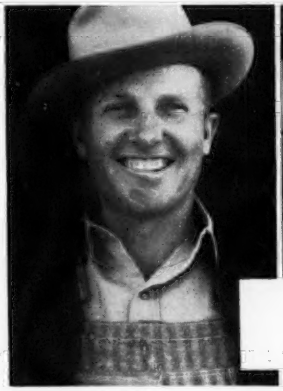
It should be pointed out in this connection that, on account of the increasing tightening of the materials situation, some of the companies indicate they may not find it possible to fill orders for safety shields due to materials shortages.

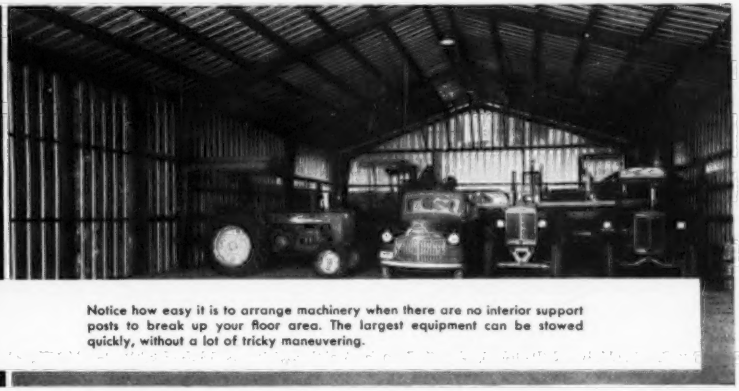
EEI Farm Session Reflects Progress

ENTHUSIASM for rural electrification as an accomplished fact and a continuing opportunity characterized the Tuesday, April 3, sessions in Chicago of the farm section at the 17th annual sales conference of the Edison Electric Institute.

In his opening remarks Chairman R. T. Jones introduced Harold H. Beaty, recently appointed rural service manager for the Institute. Mr. Beaty responded briefly, indicating that he hoped to function as a bird dog for the Institute and its members, in searching for and pointing out opportunities for them to improve their services to agriculture.

Other ASAE members contributing to the program were G. W. McCuen, head, agricultural engineering department, Ohio State University, who spoke on the formation and objectives of farm electrification state councils; and J. B. Stere, agricultural *(Continued on page 288)*





Notice how easy it is to arrange machinery when there are no interior support posts to break up your floor area. The largest equipment can be stowed quickly, without a lot of tricky maneuvering.

"Steel buildings provide safe storage for grain and machinery"

says Marvin Price, Mullinsville, Kansas

Read what a successful farmer like Mr. Price has to say about all-steel farm buildings.

"In the past few years I have found an increasing need for all-steel farm buildings in my farming operation. I erected an all-steel building this past year and find it satisfactory in every respect.

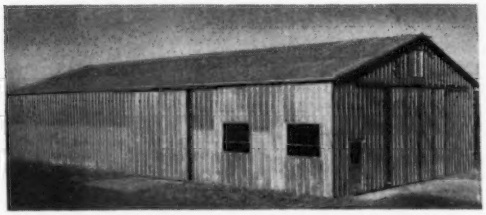
"Steel buildings are permanent, fireproof and provide a safe storage for grain and machinery against weather hazards and fire. The upkeep is practically nil.

"I find that if a farmer is to increase his profits, he has to reduce his overhead and protect his investment in machinery, and reduce the spoilage of grain. These all-steel buildings will best solve this storage problem we are all confronted with."

Steel buildings give you the most *practical* construction for your money. Steel buildings are strong and durable. They stay weather-tight because rigid galvanized steel sheets are securely attached and can take the knockabout service of everyday use.

Steel buildings can be erected with doors and windows where you want them. You *don't* need interior support posts. The obstruction-free floor space makes it easy to move and store machinery. You can use all the space.

Steel buildings are the best fire protection. This often means lower insurance costs on buildings and equipment. For more information about steel farm buildings, use the coupon below.



Strong all-steel buildings *stay* trim and neat, because they require very little maintenance. And if you ever want to sell your farm, remember steel buildings often increase the value of your farm *far more* than the modest cost of the buildings.

You get more for your money when you build with Steel

U·S·S GALVANIZED STEEL for ROOFING and SIDING

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UNITED STATES STEEL

engineer, C. A. McDade Co., who reported on farm dealer training.

High point of the farm sessions was the noon luncheon featuring an address on rediscovering America by Dr. J. O. Christianson, superintendent of the school of agriculture, University of Minnesota. Dr. Christianson spoke on behalf of free enterprise and local handling of local problems. In doing so he paid a high tribute to the electric industry, saying that it had made probably the greatest modern contribution to civilization by providing the means for improved living in homes.

During the luncheon, Frank E. Watts paid a short tribute to the memory of the late George W. Kable as one who had contributed probably more than any other one man to progress in rural electrification. At its conclusion the audience stood in silence briefly in further tribute to Mr. Kable.

The chairman expressed the appreciation of the group to J. C. Cahill for his work in developing the program, and to A. A. Pfingsten for arranging the exhibits.

Other features of the program were talks on problems arising from increased use of water on the farm, the use of radio in farm electrification, the fire insurance companies' stake in rural electrification, what electrical training has meant in 4-H Club work, generating business, and building character and reputation.

Chemurgists Confer at Cincinnati

POWER and machinery are primary means to production economy in agriculture, of interest to chemurgy, Wheeler McMillen told the 16th National Farm Chemurgic Conference in Cincinnati, April 17. His address as president of National Farm Chemurgic Council marked the opening of a three-day conference in which agricultural engineering cropped up periodically as a factor in cooperation between agriculture, science, and industry.

Continuing, Mr. McMillen pointed out that 94 per cent of the physical work in agriculture is estimated to now be done by machines. He indicated that agriculture can remain strong and provide a good living for an important part of the population by increasing its service beyond the range of primary production, through new crops, vertical diversification, farm processing and similar measures.

Chemurgy may well have been "the most constructive force generated in America during the 1930's," Frank W. Jenks, vice-president, International Harvester Co., and principal speaker at the banquet closing the conference, told his audience. He pointed out that it emphasized cooperation in free enterprise rather than government subsidy; development and production of new values rather than destruction of surpluses; preservation of the soil and other exhaustible resources, together with maximum utilization of renewable resources. He cited numerous examples of products which are the results of chemurgic progress and now in common daily use.

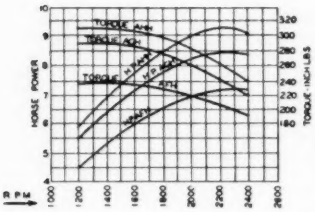
Russell R. Poynor (Member ASAE), agricultural engineer, farm practice research, International Harvester Co., was one of several new directors elected to fill vacancies on the Council's board of directors.

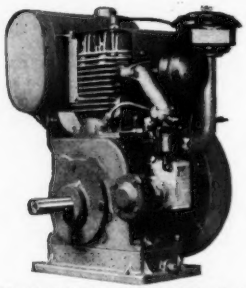
Other ASAE members present at the Conference included H. H. Beaty, Richard Boonstra, H. M. Gitlin, C. H. Jefferson, W. H. Lowry, and D. G. Womeldorff.

Four Single-Cylinder WISCONSIN *Air-Cooled* ENGINES Offering More POWER ADVANTAGE, 6 to 9 hp.

This series of single-cylinder models have all of the traditional Wisconsin heavy-duty features such as self-cleaning tapered roller bearings at both ends of the crankshaft, rotary-type, high tension OUTSIDE magneto operating as an independent unit, and maximum torque at all usable speeds.

AEH, AFH, AGH, and AHH single-cylinder standard engine models, 6 to 9 hp.





POWER CURVE AND HORSEPOWER LISTING SHOWS MAXIMUM DYNAMOMETER HORSEPOWER OF ENGINE complete with fan, muffler, and air cleaner. For continuous heavy-duty operation do not rate the engine at more than 80% of the horsepower shown at any given speed.

MODELS	AEH	AFH	AGH	AHH
Bore...inches	3	3¼	3½	3⅝
Stroke...inches	3¼	4	4	4
No. of cylinders	1	1	1	1
Displ. cubic inches	23	33.2	38.5	41.3
H.P. and R.P.M. range	3.9 at 1600	6.0 at 1600	7.2 at 1600	7.7 at 1600
	6.1 at 3200	7.2 at 2200	8.4 at 2200	9.2 at 2200
Net weight in lbs., Standard Engine	130	180	180	180
Added weight for clutch	35	35	35	35
Added weight for reduction	25	60	60	60
Added weight for clutch reduction	80	80	80	80

Third in a series about Wisconsin Engines. Entire series yours on request. For more detailed information, your inquiry is invited.

WISCONSIN MOTOR CORPORATION
World's Largest Builders of Heavy-Duty Air-Cooled Engines
MILWAUKEE 46, WISCONSIN

Personals

U. S. Allison has been transferred from his assignment as director, Caribbean area, Soil Conservation Service, USDA, to the Washington, D.C., office of SCS, with the title of assistant chief, water conservation division.

E. L. Barger has resigned as professor of agricultural engineering at Iowa State College, where he has been in charge of undergraduate and graduate instruction in farm power and machinery for several years, to accept the position of manager of farm practices research with Harry Ferguson, Inc.

Berthoud C. Boulton has joined the administrative staff of New Idea Division, Avco Mfg. Co., as product design engineer. He will correlate design and production functions and assist in any defense production work in which the company may engage. He has made significant contributions to the field of aviation engineering design and production and during World War II served as chairman of the West Coast Aircraft Production Council. More recently he was employed as chief engineer of the John Deere Des Moines Works.

W. H. De Bruin, who for some time has held the position of development engineer on farm tractor and implement tires for the Goodyear Tire and Rubber Co., has recently been promoted to the position of resident contact engineer for the Company in the Detroit area where his principal contacts will be with the automotive trade.

Allen S. Gordon has resigned as agricultural officer on farm machinery to the Food and Agriculture Organization of United Nations, to accept appointment as assistant to the general sales manager of Harry Ferguson, Inc.

Arthur Kramer has been promoted from the position of assistant superintendent of the Baker River Power *(Continued on page 290)*

A GOOD NAME ON HIGH *QUALITY* FARM MACHINERY

DIAMOND
ROLLER CHAINS

● Versatile as the farm machinery of which they are a part, Diamond Roller Chains serve on engine to main shaft drives, shaft to shaft or many shafts, and conveyor drives with equally high efficiency.

Many years of superior performance under all kinds of conditions—heavy loading, shock, fast or slow speeds, long, continuous service—have proved the quality of Diamond Drives.

As original or replacement equipment, Diamond Roller Chains uphold the high standard set by foremost manufacturers.

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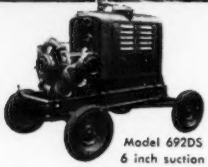
GEHL
Gehl Brothers Forage Harvester showing use of Diamond Roller Chain Drives.

BRILLION
Diamond Drive on Grain Drill and Grass Seeder Combination manufactured by Brillion Iron Works, Inc.

HUME
Diamond Drives are also used on the H. D. Hume Co. Tractor-Rower Harvester.

Marlow WATER WIZARD
SPRINKLER IRRIGATION PUMPS

. . . dependable
. . . economical
. . . easy to use

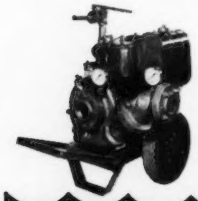


Model 692DS
6 inch suction
and discharge

Modern design — These pumps embody the latest features for modern sprinkler irrigation. Marlow Water Wizards are new . . . designed especially for today's new pressure and capacity requirements. They will supply water dependably. They are thrifty and virtually maintenance-free in operation and are built to last for years.

Complete size range — Marlow centrifugal irrigation pumps offer a wide choice of models for *any* job. Available in 14 models, sizes 2- to 6-inch, including two models designed especially for 2- and 3-acre sprinklers. Capacities 50 to 1900 GPM; pressures 30 to 200 PSI. Gasoline and Diesel engine driven; all models may be equipped for belt drive or supplied direct coupled to electric motors. Skid mounted or with steel wheels or rubber tires.

Model 312S 3 inch
suction and discharge



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Write for full information.

MARLOW PUMPS 255 GREENWOOD AVENUE RIDGEWOOD, NEW JERSEY

Manufacturers of Quality Pumps for Over a Quarter of a Century

NEWS SECTION *(Continued from page 288)*

Plant of the Puget Sound Power and Light Co. at Concrete, Wash., to advertising director of the Company at its headquarter's office in Seattle.

E. C. Meyer recently resigned as plant engineer for Milk Products, Inc., Eau Claire, Wis., to join the Minneapolis Honeywell Regulator Co., Minneapolis, as research engineer. His new work will be concerned primarily with the development of controls applying especially to the agricultural industry.

Jack K. Oakman, recently resigned as veterans' instructor in the Glen Allan Consolidated Line School at Panther Burn, Miss., to accept a position as associate inspector for the Mississippi Seed and Improvement Assn. at State College.

M. D. Stewart recently resigned as chief engineer of South Bend Plant No. 1 of The Oliver Corporation, to engage in farming. He will be located near Cedar Falls, Iowa.

Chester F. Williams has resigned as extension agricultural engineer, University of Arkansas, to become manager of the Ozark Rural Cooperative Corp. at Fayetteville, a co-op which is serving 8500 members.

Galen C. Winter, who has been a member of the Farm Equipment Institute staff at the Institute's headquarters in Chicago for several years, has been placed in charge of the Washington, D.C., office of the Institute recently established, in Room 229, Tower Building.

Necrology

ISAAC WARREN WEBSTER, branch manager of Starline, Inc., at Albany, N. Y., passed away March 5. He was born at Hebron, Ill., December 4, 1887. He was a school classmate at Harvard, Ill., of H. B. Megran, president of Starline, Inc., was associated with the latter in a grocery business from 1909 to 1914, and followed him in joining the Starline organization in 1915. After 5 years in the main office of the Company, he was made manager of the Albany branch in 1919, and had continued in that position until his passing. He was highly regarded by a wide circle of friends and business associates. Interment was at Mount Auburn Cemetery at Harvard, following Presbyterian services.

War Economy

(Continued from page 259)

Many things obscure and complicate the simple fact that what most of us are trying to do is to produce somewhere near as much as we would like to consume.

These obscuring and complicating factors do not alter the principle.

High-producing individuals and nations may always have to devote some part of their production to protection from others who would rather appropriate than produce. A realistic view shows that necessity for protection to be a tax on what we might otherwise have and enjoy, rather than an addition to it.

NEW BULLETINS

Twenty-Sixth Annual Report of the Kansas Committee on the Relation of Electricity to Agriculture. Limited circulation mimeograph of the agricultural engineering department, Kansas State College, Manhattan. Proceedings of the Committee plus special reports as follows: Report of Progress of Rural Electrification in Kansas by Frank C. Arthur, Ear Corn Grinding by Edward M. Smith, Earth Heat Exchanger Research by Ralph Lipper and Paul L. Lyman, Other Activities of the Committee by Paul L. Lyman, Heat Pumps Using Water as a Heat Source and Heat Sink by Warren C. Trent, and Report on the Heat Pump Installation at Matter's Corner by Paul L. Furbeck.

Curing Bright-Leaf Tobacco with Forced Ventilation, by E. M. Matthews, V. H. Baker, G. E. Barlow, Jr., and R. B. Davis, Jr. Virginia Agricultural Experiment Station, technical bulletin 116, January 1951. This is a report of 5 years' research in designing and operating a forced-ventilation system using heated air for curing bright-leaf tobacco. The system is reported to reduce fuel and labor costs by making it possible to lower the high temperatures usually required in the final stages of curing without prolonging the curing time and by increasing the capacity 140 to 150 per cent of normal through closer stacking, without damage from sponging or scalding or an appreciable increase in fuel. An insulated air-tight barn is required for successful operation, however, and the system does not eliminate the need for an experienced tobacco curer. The data in the bulletin may be used as a guide in curing.

● Friendly service means a lot . . . particularly to manufacturers of farm implements and tractors who have their hands full today trying to make production ends meet.

We at Cleveland Welding Company do everything possible to the limit of our capacity to help agricultural manufacturers in their trying times. This includes rendering details and quotation service on rims and circular rolled and welded steel product in volume; and everything else that goes into the making of a *friendly* and *profitable* working relationship. Come what may in the future, we'll continue to help you to the extent of our ability. If you are in the need of full cooperation from a supplier of rims or circular weldments, send us your blueprints and ask us to quote on volume requirements.

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Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Alexander, Ewell M.—Rural rep., Savannah Electric & Power Co., Savannah, Ga.

Bailey, Ryland Y.—Student, Virginia Polytechnic Institute, Blacksburg, Va.

Brooks, Lyndon A.—Project leader, Electric Research Farm, Madison 6, Wis. (Mail) Agr'l Engineering Building.

Castoriano, Maurice—Engr. trainee for foreign operations, International Harvester Co., 180 N. Michigan Ave., Chicago, Ill.

Chew, Joseph C.—Asst. service supervisor, International Harvester Co. (Mail) 2905 N. 16th St., Philadelphia 32, Pa.

Ehlers, William F., Jr.—Supervisor, Houston Lighting & Power Co., P.O. Box 1700, Houston 1, Tex.

Fletcher, Robert F.—Student, Virginia Polytechnic Institute, P.O. Box 3689, Blacksburg, Va.

Ford, Burdette R.—Farm operator, Tonica, Ill.

Gay, Robert S.—Student, Virginia Polytechnic Institute. (Mail) Victoria, Va.

Hale, John K.—Student, Virginia Polytechnic Institute. (Mail) P.O. Box 96, Narrows, Va.

Hansen, Merlin—Asst. chief engr., John Deere Waterloo Tractor Wks., Waterloo, Iowa. (Mail) 1123 Western.

Hidalgo, Chester P.—Student, Southwestern Louisiana Institute. (Mail) RR 2, Box 29, Opelousas, La.

Icely, Robert F. U.—Asst. combine engr., Massey-Harris, Ltd. (Mail) 127 Newmarket Rd., Norwich, Norfolk, England.

Kitchen, William E.—Student, Virginia Polytechnic Institute, Box 3569, Blacksburg, Va.

Lamb, Jack Gilbert—Sales engr., Sunset Engineering Co. (Mail) 704 Muse St., Albany, Ga.

Lembke, Walter D.—Graduate assistant, agr. engr. dept., University of Illinois, Urbana, Ill. (Mail) 4 Saffer Ct.

Mason, John P. H., Jr.—Student, Virginia Polytechnic Institute. (Mail) Doswell, Va.

Mayfield, Robert W.—Trainee, J. I. Case Co. (Mail) RR 3, Franklin, Ind.

McKusick, Richard D.—District agr. engr., extension service, Cornell University. (Mail) 304 Grandview Ave., Catskill, N. Y.

Monke, Edwin J.—Graduate asst. in agr. eng., University of Illinois. (Mail) Harvel, Ill.

Moss, Bud S.—Agr. agent, Georgia Power Co., 75 Marietta St., Atlanta, Ga.

Pereira, P. B. R.—Agr. dept., Sotreq S. A. de Tratores e Equipamentos, Rio de Janeiro, Brasil. (Mail) Caixa Postal, 20.

Pringle, Fred F.—Mgr., R. M. Wade & Co., 532 First Ave., S., Seattle, Wash.

Smiley, Francis W.—Chief spring engr., American Steel & Wire Co. (Mail) 221 Ridgeland Ave., Waukegan, Ill.

Smith, Roy R.—Supervisor, rural development, Pennsylvania Electric Co. (Mail) 21 West 10th St., Erie, Pa.

Stone, Alexander D., Jr.—Remington, Va.

Strickler, James H.—Student, Virginia Polytechnic Institute. (Mail) RR 1, Luray, Va.

Vriend, George—Civil engr., Bureau of Reclamation, USDI. (Mail) Gen. Del., Ephrata, Wash.

Waldrop, Thomas W.—Student, Virginia Polytechnic Institute, Box 4485, Blacksburg, Va.

White, Gerald M.—Student, Virginia Polytechnic Institute, Box 4689, Blacksburg, Va.

Wielage, Donald R.—Engr., John Deere Waterloo Tractor Wks, Waterloo, Iowa. (Mail) 1166 Patton St.

Wiley, Dorset V., Jr.—826 Waseno Ave., Roanoke, Va.

Wimberly, D. E.—Rural consultant, Arkansas-Missouri Power Co. (Mail) 1009 N. 6th St., Blytherville, Ark.

TRANSFERS OF MEMBERSHIP GRADE

Arthur, E. Keith—Engr., Bureau of Reclamation, USDI. (Mail) 457 6th Ave., Durango, Colo. (Associate Member to Member)

(Continued on page 294)

CUT DITCHING COSTS
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Faster, more complete cleaning jobs plus faster, deeper new ditches with the Briscoe Ditcher.
Cuts costs of digging a ditch to as low as $24 a ¼ mile! Largest model moves over 500 cubic yards of earth an hour.
CUTS COST TO 2¢ A CUBIC YARD
8 separate hydraulic controls give operator push-button action on steering, depth, leveling, tail support, wing angle, and spoil wings. Operates smoothly in water, thick brush, or heavy soil.
Complete demonstration for any Conservation District without obligation.
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IT CLEANS
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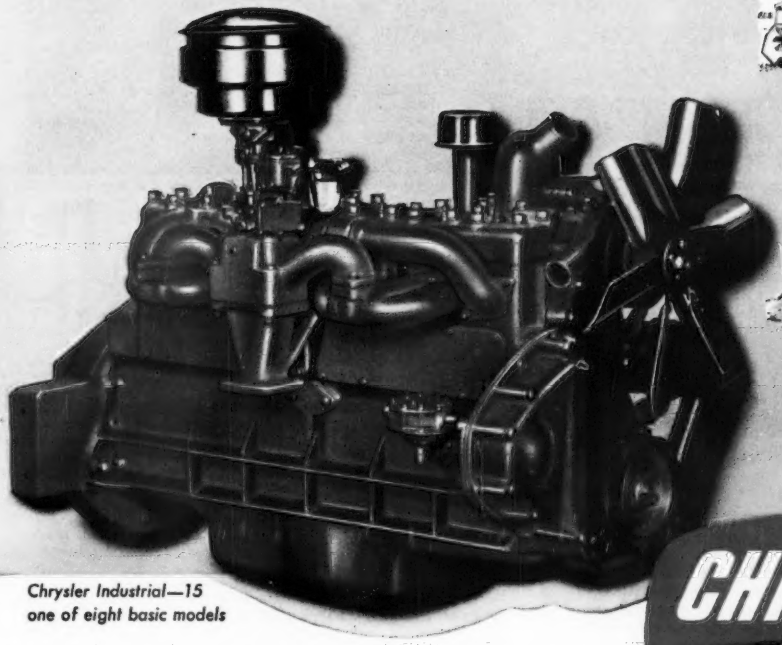

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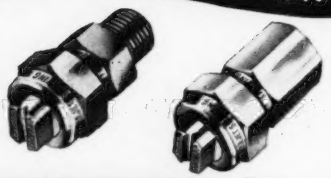
Chrysler Industrial Engines are backed by service everywhere.

A letter of inquiry will bring an engineer well qualified to discuss your application. Address: **Industrial Engine Division, The Chrysler Corporation, Detroit 31, Michigan.**

FOR AGRICULTURAL SPRAYING



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SPRAY NOZZLES

Interchangeable Orifice Tips . . . flat spray, cone spray, and disc-type cone spray. Full range of sizes for every spraying need.

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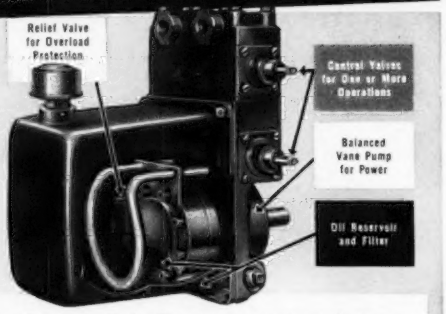
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The Power Pack offers designers and manufacturers a proven and dependable source of hydraulic power in a single compact "package". Hydraulic balance, automatically controlled operating clearances, and built-in overload protection are among the many advantages that make the Vickers Power Pack an outstanding hydraulic equipment value. Saves labor and reduces cost on agricultural implements, construction machinery, materials handling equipment, and industrial machinery.

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Write for BULLETIN 46-48

APPLICANTS FOR MEMBERSHIP

(Continued from page 292)

Friberg, W. R.—Assoc. prof. of agr. engr., University of Idaho, Moscow, Idaho. (Mail) 723 West C St. (Affiliate to Member)

Pahalwan, Rajendra N.—Research asst., agr. engr. dept., Implement Testing Station, Agricultural Institute, Allahabad, India. (Associate Member to Member)

White, James W.—Asst. agr. engr., div. of field husbandry, soils, and agr. engr., Department of Agriculture. (Mail) Central Experiment Farm, Ottawa, Ont., Canada. (Affiliate to Associate Member)

NEWS FROM ADVERTISERS

New Products and Literature Announced by AGRICULTURAL ENGINEERING Advertisers

Link-Belt General Catalog 900. This new general catalog of products of Link-Belt Co., Chicago, Ill., is a cloth bound, 8½ x 11-inch volume of 1295 pages. Sections cover Link-Belt in industry, chains and wheels, drives, transmission products, process machines, conveyors, auxiliary products, and technical information. Illustrations, tables, and text provide engineering application data on each item, type, and size in the Link-Belt line, as a help in the selection of items best suited to specific use conditions.

• • •

Link-Belt "RC" Flexible Coupling Catalog. The Link-Belt Co., 307 N. Michigan Ave., Chicago 1, Ill., has recently published a new 4-page illustrated folder, No. 2363, on its roller chain flexible-shaft couplings, which will be sent to readers on request. These couplings consist of a strand of chain and two cut-tooth sprockets or coupling halves and are designed for rugged use, easy installation, durability, reliability, and efficiency in service. Engineering information on dimensions, weights, service factors, and horsepower ratings is included for proper application. Detailed data are also given on two types of protective grease-retaining casings—plastic and spun metal revolving types—which should be used for speeds in excess of 500 rpm or at lower speeds in atmosphere laden with dust or moisture.

• • •

Stran-Steel Building Booklet. "Farm Service and Production Buildings in the National Defense Effort" is the title of a new 64-page, 8½ x 10½-inch booklet published by the Stran-Steel Division of the Great Lakes Steel Corporation. Brief text in large type, supplemented by photographs, graphs, and drawings, emphasizes the importance and need of modern farm buildings in efficient labor and material-saving farm production and storage. At the same time it pictures the manner in which Stran-Steel buildings may be used to meet a wide variety of farm service building requirements.

• • •

Dearborn Products Catalog. Dearborn Motors Corp., Birmingham, Mich., has just published a 40-page, 2-color catalog covering the Ford tractor and the Dearborn line of farm equipment. Starting with a brief history of the Ford tractor and the Ford Motor Co.'s contributions to American agriculture, the booklet shows how the modern Ford tractor has been designed with versatility in mind. Cutaway pictures show the design of the tractor and its many extra features provided by good design and mass-production techniques. The built-in hydraulic mechanism is diagrammed and explained. Action photographs illustrate modern methods of seedbed preparation, planting, cultivating and harvesting.

• • •

Sun Angle Calculator. Libby-Owens-Ford Glass Co., Toledo, Ohio, recently announced a sun-angle calculator for the use of architects and engineers in application of the sun's angular values to the design of buildings. A basic element of the calculator is a radial chart for each 4 deg of north latitude from 24 to 52 deg, showing the angle of the sun above the horizon at that latitude for every time of day and every time of the year. These charts are printed on white sheets of stiff plastic. Superimposed on the sun chart is a transparent protractor chart overlay which may be rotated about its center to adjust for the facing of windows at various angles from true south. In addition to the protractor degree scale it provides reading lines for profile angle and angle of incidence. Superimposed on this and movable about the protractor center is a transparent plastic reading arm or cursor graduated for taking off true altitude angle readings for any combination of latitude, date, time of day, and window facing shown on the calculator. The device may be used to determine quickly the true altitude, profile angle, bearing, and angle of incidence of the sun's rays for any hour of any day for any latitude from 24 to 52 deg north, for windows and walls facing any direction. It can be used to find the depth of direct ray penetration through windows, to determine the profile of shadows, to calculate dimensions and positioning of shading devices, and to estimate solar heat gain through windows. It is accompanied by an instruction booklet and charts for determining direct solar energy and sky or diffuse energy. This unit is packed in an 8½ x 8½-inch cardboard cover with snap fastener. A limited number have been prepared and are being made available to architects and engineers at $9.50 prepaid. This is said to be below cost price. Orders should be addressed to Dept. S.P., Libby-Owens-Ford Glass Co., Nicholas Bldg., Toledo 3, Ohio.

There's trouble in the air!

Wind erosion works fast! It carries thousands of tons of good top soil away each year . . . stripping farm after farm of their productive ability and destroying millions of dollars worth of crops. Dust storms are expensive!

Well-planned conservation programs furnish sound protection against all types of erosion — whether due to wind or water, or a combination of both. By following the recommended conservation practices of keeping grass and cover crops on barren areas . . . building ponds . . . contouring . . . strip-cropping . . . planting legumes . . . rotating crops . . . leaving marginal areas in timber, erosion can be controlled.

For best results, it's important that we all coordinate our efforts and set up long-range programs. Conservation is a job for all of us . . . for we who design and build farm machinery . . . for the farmers who use it . . . and for you who work with and guide our 6 million farmers.

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Manufacturers of tractors, combines, corn pickers, forage harvesters and a full line of other farm machinery, engineered and built for better farming.

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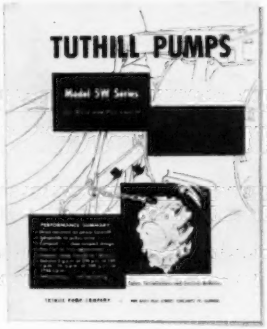
Get This Guide To Pump Service In Row-crop Spraying



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How Tuthill pumps meet row-crop spraying requirements in today's weed and pest control service is told in this illustrated bulletin. It includes complete data on models for handling both water-base and oil-base solutions of insecticides, herbicides, and fungicides commonly used for this service.

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RATES: Announcements under the heading "Professional Directory" in AGRICULTURAL ENGINEERING will be inserted at the flat rate of $1.00 per line per issue; 50 cents per line to A.S.A.E. members. Minimum charge, four-line basis. Uniform style setup. Copy must be received by first of month of publication.

Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration, or license as a professional engineer.

NOTE: In this bulletin the following listings still current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated:

POSITIONS OPEN: NOVEMBER—O-102-510. DECEMBER—O-113-514. 1951—FEBRUARY—O-168-517, 173-518. MARCH—O-186-522. APRIL—O-177-523, 193-524, 226-525.

POSITIONS WANTED: SEPTEMBER—W-40-10. OCTOBER—W-69-13, 73-14, 71-15. NOVEMBER—W-72-17, 99-18. 1951—JANUARY—W-140-25, 145-27. FEBRUARY—W-156-31, 162-33, 164-35. MARCH—W-116-36, 120-37, 172-39, 184-40, 176-41, 185-42, 188-43. APRIL—W-196-44, 197-45, 202-46, 227-47, 212-48, 222-49, 229-50, 219-51.

NEW POSITIONS WANTED

DESIGN, development, research or management, in power and machinery or farm structures field with manufacturer or consultant, anywhere in U.S.A. BS deg in agricultural engineering, 1949, Michigan State College. Farm background. Mason contracting experience during college and summer vacations. Completed industrial engineering trainee program with farm equipment manufacturer since graduation. Subsequent experience as design draftsman. War enlisted service in Army, Corps of Engineers, 1½ yr. Married. Age 24. No disability. Available on two weeks notice. Salary open. W-240-52

EXTENSION or service work in power and machinery, rural electric, or soil and water field, in public service or farming operation preferably in Arkansas or vicinity. BS deg in agricultural engineering expected in June, University of Arkansas. Farm background. Enlisted service in Army Corps of Engineers, 22 mo., including 12 mo. in Army of Occupation in Korea, in work as general electrician. Single. Age 24. No disability. Available June 15. Salary $3000 min. W-252-53

EXTENSION, teaching, research, or service, in power and machinery or rural electric field, in industry or public service, anywhere in U.S.A. Willing to travel. BS deg in agriculture, Cornell University, 1950. Several years farm experience, including 3 yr in production, processing, and marketing of hybrid corn and other quality seeds. Student instructor in farm shop 2½ yr and in farm machinery a shorter period while in college. War enlisted service in Infantry 3½ yr, including 4 mo. as operator of generator station. Additional experience as a machine operator in woodworking plant, in building construction and maintenance, and as oil burner fireman. Married. Age 27. No disability. Available on reasonable notice. Salary open. W-253-54

DEVELOPMENT, research, or teaching, in power and machinery field, with college or manufacturer, anywhere in U.S.A. BS deg in agriculture, 1950; BS deg in mechanical engineering expected June 1951, both University of Wisconsin. Farm background. Joint operator of 320-acre diversified farm 3 yr. Teaching assistant in agricultural engineering department, University of Wisconsin 1½ yr. Summer work on dairy barn research project and U.S.D.A. survey work. Married. Age 26. No disability. Available July 1. Salary open. W-237-55

TEACHING, sales, or service in power and machinery field, with college or manufacturer, anywhere in U.S.A., possibly elsewhere. Willing to travel. BS deg in agricultural engineering expected in June, Louisiana State University. General farm background. Machinist apprentice at Higgins Industries two summers. War enlisted service in Navy 20 mo. Rated boilermaker 3rd class. Single. Age 25. No disability. Available June 10. Salary open. W-276-56

DESIGN, development, research, extension, sales, or service in soil and water field with private industry in South or Southwest. BS deg in agricultural enigneering, 1950, Iowa State College. Graduate study in water control. Student assistant in agricultural engineering department part time while in college. War service in Navy 2 yr. Married. Age 23. No disability. Available July 1. Salary open. W-277-57

Complete Information on Ball Bearings

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New Departure's library of technical books for engineers and designers contains the most complete, practical and authoritative data available in the ball bearing industry.

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CODE Letter	
	BOOKS ON DESIGN
BA	Bearing Application (Part I)
DD	Details of Design (Part II)
EL	Enclosure & Lubrication (Part III)
LC	Bearing Load Computation (Part IV)
AP	Application Procedure (Part V)
LF	Full Scale Drawings of Bearings
H	Tables, formulae, bearing principles, load computation, bearing installation
	MAINTENANCE AND SERVICE
SP	Service Procedure for Ball Bearings
R	Interchangeable Replacement Bearings
FW	Front Wheel Adjustment Chart
	GENERAL
S	Standard Catalog (Handbook, Vol. I)
BI	Explanation of numbering system
D	Sealed bearings (Discussion of Principles)
IB	Sealed Bearings with provision for relubrication
BM	How Steel Balls Are Made
DE	Decimal Equivalent Tables (4 sizes)
T	Why Anti-Friction Bearings (Discussion of Fundamental Principles)

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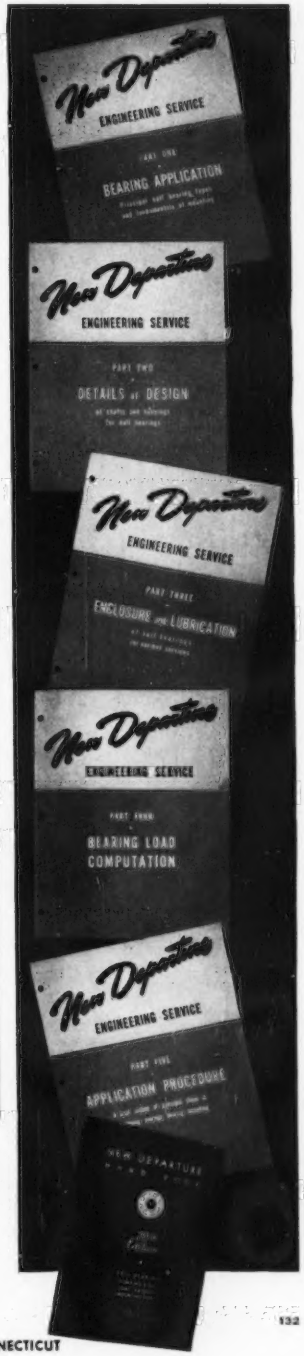

NEW DEPARTURE
BALL BEARINGS

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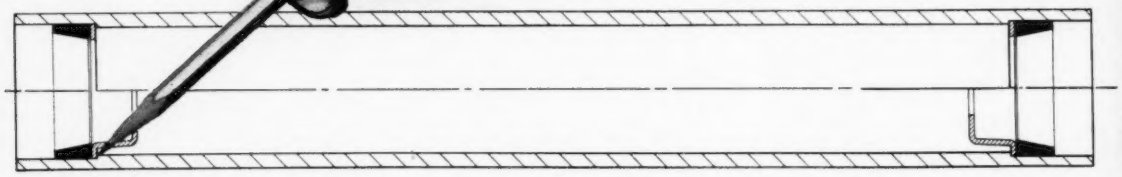
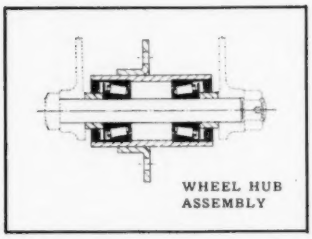
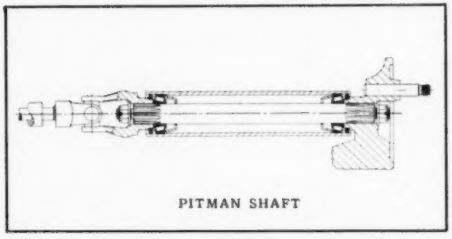
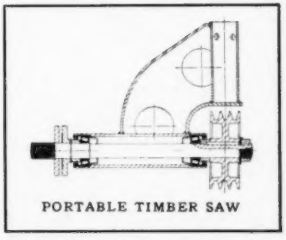
NEW DEPARTURE • Division of GENERAL MOTORS • BRISTOL, CONNECTICUT

New TIMKEN® bored seat tubing now available









You Obtain All Timken Bearing Advantages Plus Design Simplicity

New bored seat tubing now offered by The Timken Roller Bearing Company gives agricultural engineers a simple solution to many implement bearing housing problems. This economical solution means many low-priced farm implements now can be designed to offer farmers the operating advantages of Timken bearings.

This new design assures accurate bearing alignment where precise rotation of shaft or housing is required. The Timken bearings provide the proper protection against all radial, thrust and combined loads; win your fight to overcome wear and friction.

As shown in the top illustration, the Timken bearing cup seats are machined to a shoulder. Tubes are supplied with or without the cups pressed in place. Inner closures and rings for alternate cup backing designs are indicated above and below the center line. Tubes are furnished with 2¼", 2¾" and 3" O.D. and in lengths of 2½ inches to 120 inches with closures available to fit the tube selected.

Some of the proven applications of this new Timken bored seat tubing now in production are shown in the three line drawings.

Additional technical data on Timken bored seat tubing is in the General Information Section, Timken Engineering Journal, pages 1-260 to 1-264. For your free copy, drop a card or letter to: The Timken Roller Bearing Company, AE Sales Promotion Manager, Canton 6, Ohio. Cable address "TIMROSCO".

TIMKEN
TAPERED ROLLER BEARINGS

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